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Reducing Pesticide Risk Workshop Proceedings

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The Agricultural Research Service conducts research to develop and transfer solutions to agricultural problems of high national priority and provides information access and dissemination to:

- ensure high-quality, safe food and other agricultural products
- assess the nutritional needs of Americans
- sustain a competitive agricultural economy
- enhance the natural resource base and the environment, and provide economic opportunities for rural citizens, communities, and society as a whole.

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Glossary of Acronyms

AFPMB	Armed Forces Pest Management Board
AMS	Agricultural Marketing Service
ARS	Agricultural Research Service
BARC	Beltsville Agricultural Research Center
BCPDL	Biological Control of Plant Diseases Laboratory
CAST	Council for Agriculture Science and Technology
CPRC	Coastal Plains Research Center
CRADA	Cooperative Research and Development Agreement
CSREES	Cooperative State Research, Education, and Extension Service
DEC	Division of Environmental Contaminants
DOD	Department of Defense
ECL	Environmental Chemistry Lab
EQIP	Environmental Quality Incentives Program
ERS	Economic Research Service
FQPA	*Food Quality Protection Act*
GLP	*Good Laboratory Practices*
GPRA	*Government Performance and Results Act*
IBL	Insect Biocontrol Laboratory
IPM	Integrated Pest Management
MSEA	Management System Evaluation Areas
NAPIAP	National Agricultural Pesticide Impact Assessment Program
NAS	National Academy of Sciences
NASS	National Agricultural Statistics Service
NCAT	National Center for Appropriate Technology
NCAUR	National Center for Agriculture Utilization Research
NCDNP	National Center for the Development of Natural Products
NCFAP	National Center for Food and Agricultural Policy
NGIRL	Northern Grain Insect Research Laboratory
NPS	National Program Staff
NPUR	Natural Products Utilization Research
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NSTL	National Soil Tilth Laboratory
OBPA	Office of Budget and Program Analysis
OPP	Office of Pesticide Policy, EPA
PSNL	Plant, Soil and Nutrition Laboratory
SARE	Sustainable Agricultural Research and Education Program
SETAC	Society for Environmental Toxicology and Chemistry
SEWRL	Southeast Watershed Research lab
SERDP	Strategic Environmental Research and Development Program
SMSL	Soil Microbial Systems Laboratory
SRRC	Southern Regional Research Center
SWSL	Southern Weed Science Laboratory
TFVRL	Tropical Fruit and Vegetable Research Laboratory
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USFWS	United States Fish and Wildlife Service
USSL	United States Salinity Laboratory
WSL	Weed Science Laboratory

Risks, both real and perceived, from pesticides must be acknowledged and addressed in ARS pest management research programs. Adequate pest control methodology is essential for the U.S. to compete in domestic and foreign markets. Research, economic analyses and education are needed to evaluate selective pest management chemicals, both synthetic and natural, that can be used in integrated systems to reduce risks while encouraging strong U.S. agricultural production.

In order to seek outside views on issues and research priorities associated with reducing pesticide risks, federal (outside ARS) and state agencies, university scientists, alternative agriculture representatives, producers, consumers, environmental interest groups and the chemical industry were invited to a workshop to hold discussions with ARS scientists. Information from this workshop will be used to define a vision for future ARS research that will reduce pesticide risk. The research identified will be: (1) appropriate for a public-funded agency; (2) focused on the most pressing problems of society; and (3) built on resources and capabilities unique to ARS. The results of this workshop will be particularly useful to a committee currently conducting a study, *The Future of Pesticides in Pest Management for U.S. Agriculture,* for the Board on Agriculture, National Research Council, National Academy of Sciences.

Research needs that were identified in break-out group discussions are placed in four categories. These needs have not been prioritized.

General

- Identify risk mitigation strategies and evaluate their effectiveness in lowering contamination potential.
- Develop, validate, and transfer new, ecologically-based pest control technologies that can serve as alternatives to those currently in use including: natural chemicals and their analogues, biological control, less toxic pesticides, cultural practices, pest resistant crops, IPM/cropping system approaches, and more efficient application technologies to ensure delivery to targets and reduction of non-target exposure.
- Evaluate risks associated with pest control systems that utilize biotechnology or biological control agents.
- Conduct basic research to gain a better understanding of pests and their relationship to the ecosystem. Include studies on physiology, biochemistry, ecology, effects of climatic variations, and population dynamics to develop low risk pest management strategies. Prioritize current and potential future pest species, using the information gained to predict the spread of pests.
- Conduct basic research in genetic engineering to develop genetically altered organisms as a means of reducing pesticide use, monitoring for potential ecological impacts.
- Evaluate the impact, ultimately including economic implications, of various pest control strategies on the viability of various agricultural production systems in domestic and global markets.

Human and Environmental Health

- Develop models to predict pesticide residues on food, linking applications and the impacts of changing production, storage and transport systems.
- Describe and model pesticide fate in humans, including low-level exposure studies and long-term chronic effects.
- Develop and maintain a food consumption database, especially for children.
- Develop methods to decrease farm worker exposure through various means such as personal protective equipment, closed systems, etc.
- Describe and model, including watershed and non-target effects models, pesticide fate in the environment in order to determine the impacts of pesticides on ecosystems. Use monitoring to validate and update models as well as to determine the urban contribution to pollution.
- Improve methods to minimize the impacts of pest control strategies on non-target organisms.

- Continue to develop better analytical methodology for monitoring and detection of chemicals or other pest-control agents that have the potential to impact human and environmental health, including indicators of endocrine disruption.

Pest Management

- Develop or enhance existing models for use in pest management.
- Develop innovative, low risk, minor use crop pest control strategies, focusing on alternatives to current strategies that are likely to become obsolete due to regulatory constraints. Where necessary, follow the regulatory requirements for *Good Laboratory Practices* (*GLP*) in the development of any pest control materials that require EPA registration.
- Minimize problems with newly introduced pest species through improved identification and predictive techniques.
- Reach consensus on the elements that compose and define IPM. In relation to these: determine the risk values of pesticides that are used in IPM for various cropping systems; conduct national analyses of cropping systems for missing pest management tools; and develop the capability to use lab data related to genetically altered crops, pests and geographic areas to evaluate potential field impacts of pest control strategies.
- Determine the mechanisms that facilitate the development of pest resistance across various pest management strategies, both chemical and non-chemical, and incorporate this information into pest management systems.
- Develop information to incorporate IPM principles and reduce risk that can be used in guidelines for labeling and application directions for homeowner pesticide use.

Research Management

- Determine which classes of pests (weeds, insects, disease agents, nematodes, etc.) are requiring the greatest use of chemical control and assure appropriate balance of research support among the various disciplines to adequately address needs for sound pest management systems.
- Enhance technology and information transfer; use the Internet as part of this process.
- Address the gaps between scientists and lay public related to risk perception and agricultural production.
- Cooperate with the chemical industry, growers, and action agencies to facilitate the adoption of low-risk pesticide pest management strategies.
- Collaborate with other agencies, possibly through the formation of interagency workgroups, to identify critical grower needs, determine the economic impact of regulation, and support public policy decision-makers.
- Establish dialogue on research priorities with ecologists, toxicologists and economists.
- Collaborate with the scientific societies to address pest management issues.

Report Layout

The remainder of this report is broken out into three chapters. The first chapter contains written copy of the speeches given during the plenary sessions of the workshop. They have been edited by the speakers for clarity.

The next chapter, Chapter Two, is the main part of this report. This chapter contains the results of the breakout sessions held during the workshop, the workshop participants and the agenda. Participants were asked to discuss ARS research in the area of pesticide risk reduction, and then gradually narrow down and prioritize the research topics by import and relevance. This chapter shows the results of three breakout sessions (each with a more narrow focus than the first) from each of eight groups.

Chapter Three of this report includes copies of the research abstracts prepared by ARS scientists for the workshop (which were also distributed at the workshop).

Chapter One: Plenary Session Proceedings

Welcoming Remarks

K. Darwin Murrell, Deputy Administrator
National Program Staff, Agricultural Research Service

I want to welcome the participants in the *Reducing Pesticide Risk* Workshop. The aim of inviting such a diverse group is to ensure all our constituent groups have a voice in the research we do. The objective of this workshop is to get input from our customers on our research program in the area of reducing pesticide risk. The role of ARS at this workshop is to listen to our customers to understand the needs of our customers and to improve on our product. Soliciting input from customers on our research program is the first in a three-step planning process. After this workshop, we will devise a strategic plan for research and then a tactical plan for implementation. ARS leaders and researchers actively seek customer input at all phases in this process.

ARS has a long history of pesticide risk reduction research. Research in IPM is a high priority for ARS. Our hope is that your input in this process will ensure our research is timely, relevant and correctly prioritized.

There are six customer groups represented at this workshop: producers; industry; regulatory/action agencies; other Federal agencies; alternative agriculture; and environmental interests. Thank you for taking the time to attend. Your input is invaluable to us.

Keynote Address: The ARS Program in Pest Management

Robert M. Faust, National Program Leader in
Field and Horticultural Crop Entomology

It's indeed an honor to have been invited by the Workshop Steering Committee to give the keynote presentation at this most timely and important meeting. My objective is to provide a perspective for the overall pest management program in USDA-Agricultural Research Service (ARS) in general, and specifically in relation to the goals of this workshop. My presentation is divided into four parts:

1. A discussion of the USDA IPM Initiative, the commitment to the public, what is meant by IPM, where are we in clarifying what constitutes IPM adoption, and what is the ARS commitment to the initiative;
2. An overview of USDA's *Pest Management Program* as currently classified under non-chemical pest management and chemical pest management, which of the agencies are involved, the relative distribution of funds, the current ARS activities, and the relationship of the ARS efforts to the new ARS *Strategic Plan* and the new ARS *National Programs*;
3. A general description of USDA policy in relation to management of pest problems, and USDA policy on research with chemicals potentially beneficial to agriculture; and
4. Some concluding remarks centered around several relatively recent legislative and other regulatory activities that will present many new challenges for the research community, as well as extension programs, now and in the future, and as related to the topic of this particular workshop.

The USDA IPM Initiative

As many of you are well aware, IPM has become a part of federal legislation as a consequence of its environmentally friendly attributes. With attention increasingly focused on pest resistance and environmental and health issues associated with some of the broadly toxic pesticides, IPM is seen as a means to reduce the Nation's reliance on chemical pesticides. The Clinton administration, in testimony before the Congress in September 1993, made a commitment to achieve the adoption of IPM on 75 percent of the Nation's crop acreage by the year 2000. Indeed, the National IPM Initiative goal is a commitment by the federal sector to partner with the state and private sector to develop, and help farmers implement, more environmentally-sound pest management approaches that are sustainable and economical, and that are equally effective in controlling pests, while still providing the nation with an economical and safe food supply.

In meeting the commitment, operations under the *USDA IPM Initiative* have: (a) the producers in each state identifying their needs; (b) scientists at land grant institutions and USDA, such as ARS and others, developing knowledge and technology to address producer needs; (c) extension staff and others promoting implementation of programs by transferring technology to the end-users; (d) end-users providing information through a network as technology is assessed for its suitability in agriculture systems; and (e) USDA, land grant institutions, and extension services, collecting data to document impacts of IPM on pesticide use, pest levels, use of multiple management tactics, and the degree of IPM adoption.

The USDA has developed a *Strategic Plan* for the Implementation of the Initiative, which is contained in a document completed in 1994. That *Strategic Plan* helps fulfill the Administration's mandate by setting out specific objectives related to coordination, research and implementation, evaluation, and communication. Under the plan, specific strategies to attempt to meet the overall goal have been formulated for each agency, including, of course, a strong commitment from ARS. An *USDA IPM Committee* has been established as a coordinating body and to oversee the implementation and progress of the initiative and the degree of IPM adoption, address major policy issues, help construct incentives programs for IPM development and implementation, and address regulatory limitations to the development of environmentally sound tactics.

I mentioned IPM adoption, and the task of data collection for the purpose of assessing how we are doing on the USDA IPM Initiative goal as the year 2000 approaches. Two important issues continue to be discussed, analyzed and sometimes debated: What is meant by IPM, especially in terms of the farmer's perspective, and more importantly what criteria should be used for measuring IPM adoption? And there is the concept of sustainable agriculture, sometimes called "Alternative Agriculture," which Congress has defined as an integrated system of plant and animal production practices having a site-specific application. Sustainable agriculture does incorporate many current strategies such as IPM and *Best Management Practices*, but what's important is to recognize the common goals of IPM and sustainable agriculture.

There are a number of working definitions of IPM that have been generated over the past decade or so, and they are really not all that different from each other. For example:

- The *National Coalition on Integrated Pest Management* (Toward a Goal of 75 Percent Cropland Under IPM by 2000, 1994) defines IPM as "A sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks."
- The news release backgrounder for the *USDA's IPM Initiative* released in 1994 (No. 0942.94) stated that "Integrated Pest Management is a systems approach that combines a wide array of crop production practices with careful monitoring of pests and their natural enemies. Practices and methods may vary among crops and among different regions of the country;"
- The National Research Council (In *Alternative Agriculture*, 1989) defines IPM as "A pest control strategy based on the determination of an economic threshold that indicates when a pest population is approaching the level at which control

measures are necessary to prevent decline in net returns. In principle, IPM is an ecologically-based strategy that relies on natural mortality factors ... and seeks control tactics that disrupt these factors as little as possible;"

- USDA program aid No. 1506, (*USDA Programs Related to Integrated Pest Management*) published by ARS in 1993 stated that "IPM is a management approach that encourages natural control of pest populations by anticipating pest problems and preventing pests from reaching economically damaging levels. All appropriate techniques are used such as enhancing natural enemies, planting pest-resistant crops, adopting cultural management, and using pesticides judiciously".

And there are other good examples. One only has to go to the *Database of IPM Resources Home Page* and visit the *Integrated Plant Protection Center* site that contains a compendium of IPM definitions (http://ippc.orst.edu/IPMdefinitions/). This is a collection of IPM definitions and their citations in the worldwide IPM literature. In any event, IPM clearly has the goal of tying together or integrating management techniques into an ecologically based approach to minimize environmental impact, with monitoring, the use of economic thresholds, multiple management tactics, and the use of ecological information, as common elements defining IPM.

In terms of adoption and measuring adoption, the Department is cognizant that IPM can be considered to occur along a continuum, as discussed at length in *the Consumer's Union* 1996 publication, *Pest Management at the Crossroads*, from low adoption to high adoption, when measuring the adoption of management components into a systems approach. Specifically, the publication notes that while different analysts and organizations use different designations, four levels or zones in such a continuum generally can be described: *No IPM*, or simply chemical control, which corresponds to systems essentially dependent on pesticides and which do not employ basic IPM practices such as pesticide application in accord with economic thresholds; *Low Level IPM* is where farmers employ at least the most basic IPM practices, for example, scouting and application in accord with thresholds, but few, if any preventive measures; *Medium Level IPM* equating to systems in which farmers have adopted some preventive measures, coupled with efforts to cut back on broad spectrum pesticide use, protect beneficial organisms, and assure that pesticides are applied most efficiently; and *High Level, or Biointensive IPM*, the zone farthest along the IPM continuum, where farmers have integrated multiple preventive practices and, as a result, have become able to control pests without relying routinely on chemical pesticides.

Each level corresponds to progressively greater reliance on biologically based practices, such as biological, cultural and physical controls, and host plant resistance, rather than pesticides. Of course, chemical controls are a part of IPM, but the use of pesticides in IPM differs from that under conventional pest control. Where possible, IPM relies on pesticides that target specific pests, can be used at lower rates, and are less toxic to beneficial organisms. Application rates, timing, and frequency are chosen to minimize effects on beneficials, and pesticides that substitute for each other are interchanged to slow the development of pest resistance to pesticides.

The USDA Economic Research Service (ERS) in September 1994 published an *Agricultural Information Bulletin* (No. 707) titled "Adoption of Integrated Pest Management in U.S. Agriculture." The ERS employed two concepts in the definitions of IPM -- an economically-derived decision rule, as well as multiple tactics for pest management -- to arrive at a general definition of an "IPM approach." ERS identified three levels of IPM-low medium, and high-which divides IPM acres according to the number of additional tactics employed in pest management. Discussions are continuing within the Department on the adoption issue.

USDA & Agency Pest Management Programs (Chemical & Nonchemical)

I would now like to turn attention to the overall pest management program within USDA, especially in terms of the agencies involved, in terms of the *USDA IPM Initiative*, and in terms of the resources being committed to the overall programs. Congress does maintain a high level of interest in the Department's pest

management programs. Each year at the budget hearings, USDA-ARS is requested to provide informational items and answers to questions for the record, such as:

- "Describe your research activities and provide by location the funding and staff years associated with pest management research through chemical and non-chemical means; or
- "How much funding is the Department directing towards IPM and environmentally - friendly techniques; or
- "What is the status of the USDA goal to have 75% of U.S. agriculture using IPM? and
- "What research activities are being undertaken to help farmers reach this goal? or
- "What research activities is USDA undertaking to develop alternatives to comply with the *Food Quality Protection Act*?"

This year the Department has been requested to provide a report to Congress that details current programs and resources with respect to pest management activities, and how they are coordinated to accomplish IPM goals. The USDA IPM Committee is currently preparing this report for submittal to Congress by the Secretary of Agriculture.

The resources within the Department, and within ARS specifically, that are being devoted to research and action activities in pest management research through chemical and non-chemical means are given in Tables 1-3. Within USDA and across the various agencies that have funds appropriated to them for pest research and control programs (Table 1), about 30% or around $90 million of the approximately $298 million in fiscal year 97 was devoted to chemical pesticide research, with ARS devoting $27 million of that amount. The agencies utilizing these funds are ARS, Cooperative States Research, Education, and Extension Service (CSREES, whose funds are divided between research & education, and extension activities), the ERS, Forest Service (FS), and the Animal and Plant Health Inspection Service (APHIS). Funding devoted to non-chemical pest research and control programs in USDA amounts to $207 million, or 70% of the total $298 million allocated to USDA pest management programs. Of the $134 million (combining chemical and non-chemical funds) that ARS devoted to pest research and control programs, $27.4 million was used for the chemical category, or about 20.4%, and thus this represents a relatively small part of what ARS undertakes in its overall pest and pest management research efforts.

The $90 million spent in USDA for chemical pesticide research is classified into the areas of improving pesticide use patterns; IR-4 minor use; toxicology, pathology, metabolism, and fate of pesticides; the National Agricultural Pesticide Impact Assessment Program (NAPIAP); economics of pest control; and other related activities. The remaining $207 million in the Department, or the 70% of the total funds devoted to the non-chemical pest management side of the program is classified into the areas of fundamental pest biology; biological, cultural, and physical control research and action activities; host-resistance, and other biologically based tactics; and economics of pest control.

One can also examine this from an IPM and related programs view point (Table 2), keeping in mind that chemical pesticides are one of the tools that may be used in IPM strategies. In fiscal year 1997, $216 million was classified in the IPM and related programs arena, including pesticide record keeping within the Agricultural Marketing Service (AMS), the Environmental Quality Incentives Program (EQIP) out of the Natural Resources Conservation Service (NRCS), and the pesticide use surveys undertaken by the National Agriculture Statistics Services (NASS). ARS devoted the greatest percentage of these funds, ($75.6 million) on IPM and related programs, which includes its areawide and other IPM field programs, related biological control research, and IPM related pesticide research; plus the minor-use/IR-4 program, and NAPIAP, as coded in the current research information tracking system. Table 3 breaks out the various components of the ARS IPM and related program allocations, and gives the breakout of the $75.6 million in gross figures, as ARS classifies and reports it to Congress.

The ARS pest management research program is in support of the *USDA's IPM Initiative*, as well as other customer IPM and pest suppression or eradication needs, and emphasizes fundamental studies of pests and host plants and animals, classical and

augmentative biological control, and other biologically based tactics, (for example, semiochemicals, sterile insect technology, and mating disruption), plus cultural control and host resistance, physical control, integrated systems, and, of course, chemical control. Target pests include a multitude of insects, mites and ticks, plant pathogens and nematodes, and weeds. In direct support of the *USDA IPM Initiative*, an areawide pest management program has been developed by ARS in collaboration with other Federal and state agencies, and the private sector. Current programs include leafy spurge, codling moth, corn rootworm and pests of stored grains.

Table 1: USDA Appropriations for Pest Research and Control Programs (Dollars in Millions, FY1997)

Agency	Chemical*	Non-Chemical**	Subtotal
ARS	27.437	106.799	134.236
CSREES:			
Research	8.243	26.643	34.886
Education/Extension	10.497	3.500	13.997
ERS	1.500	1.000	2.500
FS	1.585	7.930	9.515
APHIS	41.428	61.496	102.924
TOTAL	**90.690**	**207.368**	**298.058**

*Chemical research includes: Improve pesticide use patterns; IR-4 minor use; toxicology, pathology, metabolism, and fate of pesticides; food surveys; NAPIAP; economics of pest control.
**Non-chemical includes: Fundamental biology; biologically based, cultural and physical control; economics of pest control.

Table 2: USDA Integrated Pest Management and Related Programs (Dollars in Millions, FY97)

AMS (Pesticide Recordkeeping)	2.556
APHIS (Biological control, Plant Methods Development Laboratories, Pink Bollworm, Fruit Fly Exclusion & Detection, Sweetpotato Whitefly)	34.493
ARS (Areawide & IPM, Biocontrol, Research, Minor-Use/IR-4, NAPIAP)	75.612
CSREES Research (IPM Research Grant, Emerging Pest & Disease Issues/Pest Management Alternatives, Expect IPM Decision Support System, Formulas & Pesticide Grants, NRI, SARE, Minor Use Clearance/IR-4, Minor Crop Pest Management, Hatch Act, NAPIAP)	58.441
CSREES: Extension (IPM application, NAPIAP, Application Training)	13.997
ERS (IPM Research, Pesticide Use Analysis, NAPIAP)	2.500
FS (IPM Research, IPM Application, NAPIAP)	16.117
NRCS-EQIP (IPM Application) (Environmental Quality Incentives Program)	6.617
NASS (Pesticide Use Surveys)	5.700
TOTAL	**216.033**

Table 3: USDA Agricultural Research Service, Integrated Pest Management and Related Programs (Dollars in Millions, FY97)

IPM Initiative - Research & Extension To Address Producer Identified Needs Areawide IPM Research	5.915
Ongoing Research & Application Programs	
▪ IPM Research	12.629
▪ Biological Control Research	53.770
IR-4 Pesticide Clearance	2.105
NAPIAP	1.193
TOTAL	**75.612**

Some specific representative examples of the ARS chemical pesticide research efforts as related to the major focus of this workshop include:

- Remediation tactics for pesticide-contaminated soils;
- Ways to eliminate or minimize chemical residues;
- Improvements in pesticide application technology, including efficient and effective use in IPM systems, reducing drift, reducing rates; improved formulations; chemigation and computer-controlled irrigation systems for site specific pesticide application; and in general new technologies to reduce human exposure to pesticides;
- In-house and cooperative research to evaluate select chemical pesticides potentially beneficial to agriculture, so as to address crises that develop as a result of the introduction of an exotic pest, such as was the case with the silverleaf whitefly; another example would be the evaluation and identification of chemical pesticides with a low order of toxicity to natural enemies; a case in point has been problems that cropped up with the boll weevil eradication program and secondary pest outbreaks; ARS also undertakes cooperative work with the Department of Defense (DOD) in development and evaluation of repellents for arthropods affecting man;
- Improved detection and measurement of pesticides and metabolites.
- Evaluation research in terms of candidate materials relative to risks to the environment, and to human health and safety to provide data on absorption and translocation, degrees of selective action on various species, metabolic fate in plants and animals, movement and fate in air, soil and water, persistence, movement in food chains, and other data that are accumulated under a wide variety of ecological and environmental conditions;
- Activities in the NAPIAP;
- Pesticide resistance management studies, especially in terms of IPM;
- Research is also being undertaken in the Management System Evaluation Areas (MSEA) related to watersheds and the development of farming systems to overcome problems in watersheds, i.e., water table management and runoff and leaching losses of soil applied pesticides, or evaluation of herbicide formulation, diluents and surfactants for best management practices.
- Determination of the value of wetland areas in protecting surface waters from agricultural runoff, buffering capacities of wetlands in agricultural settings, as well as reclamation of wetlands;
- Research on the impact of cover crops on herbicide efficacy and fate;
- Cooperative work with APHIS' programs to control cattle ticks; for example development of a microbial biodegradation process to reduce coumaphos concentrations;
- Minor-use pesticide research related to efficacy, phytotoxicity, persistence and residue data, and other requirements for registration and re-registration.

In terms of the new ARS *Strategic Plan* and the new ARS *National Programs*, of which

there are 25 that have been recently developed to more effectively respond to customer needs and the *Government Performance Results Act* (GPRA), the ARS pest management research efforts crosscut a number of them. The major ones include:

- the Plant Diseases National Program;
- the Crop & Commodity Pest Biology, Control, and Quarantine National Program;
- the Integrated Crop Production and Protection Systems Program;
- the Integrated Farming Systems National Program;
- Animal Pests and Parasites National Program;
- the Water Quality & Management;
- the Soil Quality & Management;
- the Air Quality National Programs;
- the Food Safety National Program; and
- the Methyl Bromide Alternatives National Program.

All of these ARS National Programs have components related to the pest management arena in one way or another. Also, each of the 25 *National Programs* are linked to the outcomes, objectives and strategies of the new ARS *Strategic Plan* and the relationships are so indicated in each of the *National Program Statements*. The input from this workshop should help provide ARS with some specific guidelines of what priorities should be addressed in meeting the overall goals and objectives of the *National Programs* and *the Strategic Plan* in terms of its pesticide research efforts.

USDA Policy on Management of Pest Problems and Research to Evaluate Chemicals

Since the late 1970's it has been the policy of the USDA to develop and encourage the use of IPM methods, systems, and practices that are practical, effective and energy-efficient. The policy, as articulated in *USDA Memorandum No. 1929*, is to seek adequate protection against significant pests with the least hazard to humans, their possessions, wildlife and the natural environment. Additional natural controls and selective measures to achieve these goals are to be developed and adopted as rapidly as possible. Embodied in the policy are five important mandates. The *USDA IPM Initiative* builds onto this overall policy and its mandates. The Department will:

- Give special emphasis to the development and use of efficient and environmentally-acceptable IPM systems. It will select all methods, including pesticides, for use in pest management programs on the basis of their appropriateness and relative safety. In the case of chemical pesticides lower risk pesticides are of prime interest and most desirable;
- Conduct and support research on: (a) development and use of resistant crops and livestock, beneficial organisms, cultural methods, selective biological and *chemical* pesticides, other innovative methods, and systems for integrating these elements; (b) basic and theoretical biology of pests to stimulate innovations potentially useful in managing pests; and (c) the economics of pest management methods, systems and strategies, including research on the feasibility of insurance against risk of losses;
- Conduct cooperative projects which demonstrate the latest in pest management technology and expand pest management education and technical assistance for homeowners, farmers, ranchers, and woodland owners;
- Improved coordination among Departmental agencies with other federal, state, and private organizations and agencies, and with interested people and groups to develop and encourage the use of ecologically sound pest management systems; and
- Assist the Environmental Protection Agency (EPA) and industry in facilitating the development and registration of selective pesticides and biologically based products needed in pest management programs.

In 1988, *Directive 600.3* from USDA-ARS articulated policy on research to evaluate chemicals potentially beneficial to agriculture, and includes chemical pesticides. To achieve its mission, ARS will encourage scientists to evaluate the effectiveness and environmental safety of biologically active and otherwise useful chemicals and formulations that are potentially beneficial to agricultural production,

and for the protection of crops and agricultural products. Much of this work is done cooperatively. ARS is especially interested in chemicals that have a low order of toxicity to man, livestock, crop and forest plants, and that are compatible with a quality environment. The agency recognizes that pesticidal chemicals are needed for use as antiparasitic agents, attractants, defoliants, fumigants, fungicides, herbicides, insecticides, nematicides, growth regulators, repellents, seed protectants, and for other agricultural uses.

Many of the chemical pesticides useful for these purposes have been synthesized and developed by industry, sometimes with the aid of the USDA's research agencies, or with other public research agencies. In some instances, the chemicals have been discovered by personnel in ARS, or other public research agencies with subsequent commercial development by industry. Generally, USDA's programs of synthesis and analysis relate to long-term basic problems such as chemical investigations of naturally occurring products and certain classes of chemical pesticides of importance to specific pest control programs, in which the USDA is engaged.

Evaluation research undertaken by ARS provides valuable information often on a nationwide basis of properties of candidate materials relative to risks to the environment and to human health and safety. ARS will conduct research on agricultural chemicals when: (a) they fit into an ARS program need; (b) adequate personnel and facilities are available; and (c) ARS believes that the research will serve the best interests of the public. However, USDA cannot assume the role of a public testing service for pesticides, for the sole purpose of establishing commercial utility of proprietary materials.

Challenges & The Future

It is clear that some relatively recent legislative and other activities will present many new challenges for the research community, as well as extension programs, now and in the future. The *Food Quality Protection Act* of 1996, will require the development of alternative pest management approaches to replace pesticides removed from the marketplace as a result of regulatory action. The organophosphates and carbamates, (and the *B1* and *B2* carcinogens) seem to be particularly at risk. New chemistries have come on the market from industry and should be a help. Extension education programs will continue to be needed to help farmers and others to implement new approaches to managing pests. NAPIAP could take on additional importance with the *Act's* implementation. NAPIAP can provide the EPA critical decision-making information regarding the evaluation and estimation of regulatory impact on pest management issues in minor cropping systems.

A new study entitled "The Future of Pesticides in Pest Management for U.S. Agriculture" is being organized by the National Research Council at the request of the USDA and the EPA. This study will address current and future pesticide use in production, processing, storage, and transportation of field crops, fruit, vegetables, ornamentals, fiber, and livestock. A review of human and environmental health aspects will also be included. The Committee will suggest an appropriate role for the public sector, USDA in particular, in research that contributes to pesticide product development, testing, registration, implementation of usage strategies, public education, and pesticide risk reduction.

And there are other important considerations and challenges such as the *Clean Water, Clean Air, Pollution Prevention, Safe Drinking Water,* and *Coastal Zone Management* Acts, EPA's *Endangered Species Protection Program* and its *Safer Pesticide Policy*, the *Sustainable Agriculture Research & Education Program*, the establishment of the new *USDA Office of Pest Management*, and indeed the Administration's IPM goal itself. Challenges do lie ahead of us and we hope that the input from this workshop will help aid ARS to formulate approaches to meet some of those challenges in the most appropriate way, and within the Agency's mission. I thank you very much for your kind attention; please enjoy the sessions and activities that have been planned for you over the next two-and-a-half days.

Charge to Participants

Michael D. Jawson
ARS National Program Leader, Soil Science

We are looking for input on our research program in pesticide risk reduction. You are charged to provide ARS with a list of prioritized research needs. To do this, we suggest you begin by brainstorming: write down all issues of concern to you or the groups you represent on pesticides. Be forthright. State all the issues and concerns you have. Do not hold back. It is only through a complete consideration of topics that we will best be able to meet your needs. We only ask that all issues and discussions be presented in a civil manner.

Use foresight here: don't just think about issues in the news today, but try and identify issues that you think will come up in the near and distant future. Next, we will ask you to narrow down your list to a manageable number of items. These items will represent topics of concern to all ARS constituents, as your group will be comprised of representatives of all or most of our constituent groups. Finally, we will ask you to attach research questions to these broad topics. This will be a learning experience for us. Therefore, we all will need to be flexible as we work our way through this process.

Ideally, this is an open process. To our customers, we ask that you be thoughtful and practice foresight and vision. To ARS staff and scientists, we ask that you be open-minded and listen carefully--the input you receive here is invaluable.

Pesticide is a word that carries a lot of baggage, to the extent that I would prefer not to deal with the passion the topic generates. However, I need to be here and participate in efforts to foster research that will promote risk reduction. When I think of the pesticide issue, I think of oceans of opinion, seas of controversy, rivers of policy, streams of data, pools of knowledge, but only drops of wisdom. With your help, I'm confident we can devise research to increase our knowledge and wisdom.

Workshop Summary

Nancy Ragsdale
Director, USDA National Agricultural Pesticide Impact Assessment Program

This workshop focused on addressing what role ARS should have in the area of pesticides, and in this role, should research be long-term, high risk; short-term; or long-term in a shorter time. This workshop was an information-gathering step. This will be followed by analysis and development of a plan, which will then be implemented.

Many USDA-ARS customer groups will use this report. It will be particularly useful for a new study initiated by the Board on Agriculture, National Research Council, National Academy of Sciences: *The Future of Pesticides in Pest Management for U.S. Agriculture*. This study will identify when and where synthetic, organic chemicals will likely continue to be necessary and determine which synthetic, organic chemicals now available or being developed would be the likely tools for future use. It will also explore the most promising opportunities, particularly those not being adequately pursued, for reducing health and environmental risks. In conclusion, the study will suggest an appropriate role for the public sector, USDA in particular, in research that contributes to product development, testing, registration, implementation of usage strategies, public education, and risk reduction.

Introductory remarks pointed out that the workshop was recognized as important in helping ARS develop a relevant plan that will encourage the movement of more agricultural production into IPM. An emphasis was placed on the importance of continuing IPM implementation as the *Food Quality Protection Act (FQPA)* impacts our pest management tool box. IPM does not mean "no pesticides;" pesticides play a role in IPM. Following the introductory remarks, an overview presentation provided background on the ARS investment in

research related to chemical pest management.

Because much of the workshop discussion repeatedly touched on *FQPA*, a brief summary of that act was provided in summary statements. *FQPA*, which amended the *Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)* as well as the *Federal Food, Drug and Cosmetic Act (FFDCA)*, was passed unanimously by Congress and signed by President Clinton on August 3, 1996. *FQPA* amended the Delaney Clause by removing pesticides from inclusion in *FFDCA* Section 409. It established a single health-based safety standard, *reasonable certainty that no harm will result from aggregate exposure*, for setting pesticide residue tolerances in raw and processed food. Aggregate exposure refers to the combined risk from all exposures to a specific pesticide from food and non-occupational sources, including residential uses, lawn/garden care and drinking water. In addition, consideration must be given to exposure to all other pesticides with a common mechanism of toxicity. The potential of a pesticide to disrupt the endocrine system will also be evaluated. For the most part, benefits of use will no longer be considered in the evaluation process. Passage of *FQPA* was strongly influenced by recommendations of the 1993 National Academy of Sciences study, *Pesticides in the Diets of Infants and Children.*

Customer groups presented the following needs/concerns:

- Better ways to transfer information, as well as technology, to the right places.
- More knowledge in order to avoid adverse effects on human health and the environment.
- Interdisciplinary groups, including scientific, socioeconomic and political components, to address pest management for specific commodities.
- Research to support better methodology for assessing long-term impacts of various approaches to pest management.
- Education on agricultural production for the public.
- In view of the regulatory framework, determine what is needed to have agriculture that is truly sustainable and competitive in a global market. Special emphasis should be given to minor crops and minor uses, such as post harvest treatment, that will be severely impacted by *FQPA*.
- Pest management for the urban environment.
- Data that will contribute to more scientifically-based regulatory decisions, including risk mitigation strategies.
- Discussion and collaboration between regulators and regulatees, including those that bridge the gap.
- Data generation, including scale-up from laboratory to field, after a system or model is developed, to confirm anticipated results or fill data gaps to correct a system or model.
- Collaboration with economists to determine viability of alternatives to chemical pest control.
- Research that demonstrates pest management approaches that are most suitable for areas friendly to wildlife.

Research priorities gleaned from eight discussion groups were:

- Sustainable systems development, including IPM.
- Data supporting estimation of long-term chronic effects on human health and the environment.
- Improved methodologies to assess the impacts of new products and alternative practices on agricultural production systems.
- Development of viable alternatives to current pest management practices, particularly on minor uses.
- Strengthened major ARS collaborations with ecologists (especially terrestrial), toxicologists, and economists.

Chapter Two: Breakout Group Results

Synopsis

The workshop was organized into break-out sessions followed by reports of each group. Session One was a brainstorming discussion devoted to brainstorming the question "What are the problems, concerns and issues associated with pesticide use in U.S. agriculture?" Session Two refined, focused, and added to the material gathered in Session One. The problems, concerns and issues discussed in these two sessions fell into these general categories:

- Food Safety
- Environmental Quality
- Ecological/Human Health Impacts
- Urban/Rural Interface (culture conflicts)
- Mitigation Strategies
- Risk Assessment Needs
- Regulatory Policy
- Maintaining Economically Viable Farm Systems
- Risks Associated with Alternatives to Conventional Pesticides
- Impediments to More Diversity in Pest Management
- Education Needs of Growers and the General Public
- Collaboration Among All Entities Associated With Pesticide Use and Research

Research Needs

Session Three focused on identifying research that would help address the problems, issues and concerns expressed in Sessions One and Two. Suggested research areas are shown here. These research needs have been placed in four categories. They have not been prioritized.

General

- Identify risk mitigation strategies and evaluate their effectiveness in lowering contamination potential.
- Develop, validate, and transfer new, ecologically-based pest control technologies that can serve as alternatives to those currently in use including: natural chemicals and their analogues, biological control, less toxic pesticides, cultural practices, pest resistant crops, IPM/cropping system approaches, and more efficient application technologies to ensure delivery to targets and reduction of non-target exposure.
- Evaluate risks associated with pest control systems that utilize biotechnology or biological control agents.
- Conduct basic research to gain a better understanding of pests and their relationship to the ecosystem. Include studies on physiology, biochemistry, ecology, effects of climatic variations, and population dynamics in order to develop low risk pest management strategies. Prioritize current and potential future pest species, using the information gained to predict the spread of pests.
- Conduct basic research in genetic engineering to develop genetically altered organisms as a means of reducing pesticide use, monitoring for potential ecological impacts.
- Evaluate the impact, ultimately including economic implications, of various pest control strategies on the viability of various agricultural production systems in domestic and global markets.

Human And Environmental Health

- Develop models to predict pesticide residues on food, linking applications and the impacts of changing production, storage and transport systems.
- Describe and model pesticide fate in humans, including low-level exposure studies and long-term chronic effects.
- Develop and maintain a food consumption database, especially for children.
- Develop methods to decrease farm worker exposure through various means such as personal protective equipment, closed systems, etc.
- Describe and model, including watershed and non-target effects models, pesticide fate in the environment in order to determine the impacts of pesticides on

ecosystems. Use monitoring to validate and update models as well as to determine the urban contribution to pollution.

- Improve methods to minimize the impacts of pest control strategies on non-target organisms.
- Continue to develop better analytical methodology for monitoring and detection of chemicals or other pest-control agents that have the potential to impact human and environmental health, including indicators of endocrine disruption.

Pest Management

- Develop or enhance existing models for use in pest management.
- Develop innovative, low risk, minor use crop pest control strategies, focusing on alternatives to current strategies that are likely to become obsolete due to regulatory constraints. Where necessary, follow the regulatory requirements for *Good Laboratory Practices* (*GLP*) in the development of any pest control materials that require EPA registration.
- Minimize problems with newly introduced pest species through improved identification and predictive techniques.
- Reach consensus on the elements that compose and define IPM. In relation to these: determine the risk values of pesticides that are used in IPM for various cropping systems; conduct national analyses of cropping systems for missing pest management tools; and develop the capability to use laboratory data related to genetically altered crops, pests and geographic areas to evaluate potential field impacts of pest control strategies.
- Determine the mechanisms that facilitate the development of pest resistance across various pest management strategies, both chemical and non-chemical, and incorporate this information into pest management systems.
- Develop information to incorporate IPM principles and reduce risk that can be used in guidelines for labeling and application directions for homeowner pesticide use.

Research Management

- Determine which classes of pests (weeds, insects, disease agents, nematodes, etc.) are requiring the greatest use of chemical control and assure appropriate balance of research support among the various disciplines to adequately address needs for sound pest management systems.
- Enhance technology and information transfer; use the Internet as part of this process.
- Address the gaps between scientists and lay public related to risk perception and agricultural production.
- Cooperate with the chemical industry, growers, and action agencies to facilitate the adoption of low-risk pesticide pest management strategies.
- Collaborate with other agencies, possibly through the formation of interagency workgroups, to identify critical grower needs, determine the economic impact of regulation, and support public policy decision-makers.
- Establish dialogue on research priorities with ecologists, toxicologists and economists.
- Collaborate with the scientific societies to address pest management issues.

Complete Break-out Group Results of the Question:

What are the Concerns, Problems and Issues Associated with Pesticide Use in the United States?

This chapter summarizes the findings and recommendations of each group at the workshop. The groups were constructed to have a representative from each of the six broad constituencies of ARS, when attendance allowed. In the appendix, there is a list of participants with their addresses, phone numbers and e-mail addresses and the participants of the workshop by constituency group. The next section of this chapter lists each group and the summary of their discussions in the breakout sessions.

Each group prepared a summary for each of three breakout discussion sessions. The results follow. The first session's aim was to brainstorm about research issues and questions important in reducing pesticide risk. Accordingly, the lists that resulted from that session are long and detailed. The second session's aim was to focus the ideas from the first session into a more compact, coherent list of issues. Finally, in the third session, each group devised a limited number of research objectives to provide feedback to ARS on research in the area of reducing pesticide risk. Overall, each session focused the discussion of the previous session.

Group A

Stuart Cohen, Environmental & Turf Services, Inc.
Anthony Barrington, AVA Chemical Ventures
Neil Anderson, USEPA
Rex Dufour, NCAT
Jim Anderson, USDA-ARS-WSL
Robert Larkin, USDA-ARS-BCPDL
Nancy Ragsdale, USDA-ARS-NAPIAP
Don Wauchope, USDA-ARS

Facilitator: John Radin, USDA-ARS-NPS
Flip Chart Operator: Clinton Truman, USDA-ARS-SEWRL
Recorder: Lloyd Southwick, USDA-ARS

Breakout Session One: Brainstorm

1. Food safety issues (residues on food).
2. Environmental fate and movement.
3. Food availability /food prices.
4. *FQPA* and alternatives to current practices (short-term need).
5. Net returns to farmers:
   - Efficiency with specific rather than broad spectrum agents; and
   - Production shifts to overseas.
6. Better prevention of introduced exotic pests:
   - Quarantines; and
   - Better prediction, detection, early eradication.
7. No common ground between public and scientist perceptions of risk:
   - Consensus risk definition is important; and
   - Education of consumers needed (or is it education of scientists?).
8. Inadequate definition of risk from biotechnology as alternative:
   - Gene transfer from herbicide resistant crops; and
   - Export markets.
9. Risk mitigation strategies (short term):
   - Buffer strips;
   - Better application technology;
   - Encapsulation;
   - Reduction of worker exposure; and
   - Models for offsite transport, assessment of exposure.
10. Too little analysis of organic systems to extract best practices.

11. More development of natural chemicals and analogues.
12. Too little evaluation of novel materials for "smaller needs".
13. Need better tech transfer/user info networks.

Breakout Session Two: Focusing Needs

1. Address needs generated by *FQPA* (highest priority).
2. Develop mitigation strategies to reduce exposures, such as: buffer strips:
- Better application technology, including attracticides or other means to reduce pesticide contact with food; and
- Encapsulation/formulation.
3. Create and validate models relating residues to actual pesticide practices.
4. Develop probabilistic risk assessment models based on actual exposure (measured or modeled) rather than worst-case assumptions.
5. Develop better models predicting environmental fate and movement of pesticides.
6. Create alternatives to current arsenal of pesticides:
- Analyze organic systems to learn more about a non-pesticidal system;
- Develop natural chemicals and analogues more intensively; and
- Evaluate more novel materials for "smaller needs."
7. Improve technology transfer and information transfer–show customers that adopting new technology does not increase risk.
8. Gap between public and scientists perceptions of risk.
9. Prevention of introduced exotic pests.
10. Inadequate delineation of risk from narrowly based alternative technologies (biotechnology).

Breakout Session Three: Final Ideas

1. Address needs generated by *FQPA:*
- Identify risk mitigation strategies and evaluate their effectiveness (ARS lead role and partner role);
- Develop food consumption database, especially for children (high-risk groups) (ARS lead role and partner role);
- Track actual pesticide residues on foods as related to original pesticide use practices, develop models to predict residues from data on pesticide applications (ARS lead role);
- Describe and model pesticide fate in the environment and in humans (ARS lead role and partner role);
- Develop, validate, integrate, and transfer alternative pest control technologies: (ARS lead role and partner role):
  - ➢ Other systems (organic);
  - ➢ Natural chemicals/analogues;
  - ➢ Biological/biorational control;
  - ➢ Other classes of pesticides;
  - ➢ Cultural practices; and
  - ➢ Pest-resistant crops.
  - ➢ IPM and systems approach to above.
- Technology transfer and information transfer is part of all research efforts and is incorporated into all approaches; and
- Areawide demonstrations when appropriate (ARS partner role).
2. Broaden research capabilities to address gap in risk perception between lay public and scientists (add relevant disciplines not now available) (ARS support role).
3. Minimize problems with new introduced pest species:
- Develop better identification and predictive techniques to prevent introduction and spread (ARS lead role); and
- Contain and control established exotic pests (ARS lead role).
4. Better define and assess risk from narrowly based alternative techniques (ARS lead role and partner role).

Group B

Leonard Gianessi, NCFAP
Raymond Forney, DuPont Agricultural Products
Michael Barrett, USEPA
Joseph Bagdon, USDA-NRCS
David Frieders, City of San Francisco
Douglas Buhler, USDA-ARS-NSTL
Gerald Larson, USDA-OBPA
Clifford P. Rice, USDA-ARS-ECL

Facilitator: Cathleen Hapeman, USDA-ARS-ECL
Flip Chart Operator: Steven Lehotay, USDA-ARS-ECL
Recorder: Martin Locke, USDA-ARS-SWSL

Breakout Session One: Brainstorm

1. Definition of IPM? How do we define success in implementation?
2. Not much distinction made among types of pesticides ... need better characterization of pesticides... toxicity, herbicide, insecticide, biopesticide (these are chemical even though they are “bio”) .... What is the toxicity of “natural” or “bio” pesticides? There is a great range in toxicity.
3. Broader spectrum of pests controlled with individual pesticides .... e.g., you may get broader spectrum of control with herbicides, but an insecticide might only go after a narrow range of insects ... so don’t try to apply IPM models of insect control to the control of weeds ... weed control is different from insect control
4. There may be a conflict between, say, using no-tillage to improve soil and reduce soil loss and the increase in overwintering habitat or increase in need for weed control. .. Reduced risk *vs*. reduced usage
5. Urban/agricultural interface... wrong perceptions, different perspectives in risk, public perception issues, need for education of both farmers and public ... the farmer needs to be able to financially survive the “education” process (i.e., the long-term benefits)
6. Better integration of management options.... Need integrated research ... team efforts.... Systems approach....
7. What do we need in a systems approach? Nutrients, ecology, economics, health, environmental, pests.... note: pest control is only one part of this.
8. What kind of risk (environmental, ecological, health)?
9. Impact of new legislation on farmers..... Too much change too fast may damage financial health of agriculture ... Need to implement some changes slowly.... Balance of priorities and costs..... Is the legislation feasible, practical, workable, and economical? Costs *vs*. benefits.
10. Should we develop technology or should we study how technology fits within and impacts a system.... e.g., transgenics, should we develop them as a product or should we evaluate how they can fit in a system? We in ARS may be the only ones who can take the long-term, resource-intensive risk of doing systems type research. However, there are specific problems which need to be addressed. Should we do a little of both ... continuum in concert with industry, universities, and other agencies?
11. There seems to be a lack of communication, cooperation, coordination among agencies
12. What are the alternatives to using chemicals for pest control? There is a large (10-15 year) lag in new products coming out on the market ... There is a concern that the top-driven goal of reducing risk is out of synch with options, alternatives, and methods to accomplish those goals.
13. So, how do we balance our research efforts in supporting existing technology, which we will probably have to use for many more years? Are we giving enough support to long-term research where we

don't have a readily obvious "product" (thus, it is boring to the politicians and administrators who want *results*)?

14. Is private industry going to look into alternatives? What are their priorities? Then what should the public sector do?
15. What is reduced risk? Specific to the locale and situation
16. There may be unknown risks.... ones we haven't even discovered.
17. Problems associated with pesticide use:

- Cost of development;
- Misuse;
- Off-target dispersal;
- Pesticide resistance;
- Loss of products and options; and
- Wrong perceptions.

Breakout Session Two: Focusing Needs

1. Lack of sufficient database:

- Non-target effects: environmental fate, biological risk on wildlife and humans, risk assessment methodologies;
- Critical grower needs;
- Regional modeling;
- Pest population biology; and
- Economic impact of regulation.

2. Lack of alternatives:

- Efficacy of present products/practices;
- Mitigation of present products/practices;
- Alternatives to pesticides;
- Implementation of organic practices;
- Integration in cropping systems; and
- Assess risks and economic viability of alternatives.

3. Protection of minor crops.
4. Improved communication:

- Technology transfer to farms and professionals;
- Among agencies and organizations;
- Non-agricultural community; and
- Novel approaches (Internet).

5. Public policy supporting alternatives:

- Areawide programs.

Breakout Session Three: Final Ideas

1. Human health:

- Small animal/tissue culture model systems;
- Small animal studies with low level pesticide exposures;
- Impact on endocrine systems?; and
- What are the impacts of low level food/environmental residues or pesticide exposure to endocrine systems? Carcinogenicity? Teratogenicity? Mutagenicity?

2. Develop innovative, low risk, minor use crops pest control strategies.
3. Determine economic impact of new, low-risk pest control strategies on viability of agricultural systems.
4. What are sociological impacts of weed encroachment into agricultural systems?.
5. Evaluate risks associated with pest control systems that utilize biotechnology: fate/transport, toxic effects, unknown risks, human health, genetics, population shifts, single approaches *vs.* broad, integrated approaches.
6. Develop and evaluate effective farm systems that mitigate pesticide risk.
7. Do basic research! Examine the physiology, biology, ecology of pests and related systems for the end goad of developing low risk pest management strategies.
8. Develop, evaluate and integrate safer/alternative chemistries in farm systems, including application technologies.
9. Research and develop in cooperation with industry, producer growers, action agencies to facilitate adoption of low risk pesticide pest management strategies.
10. Impact of pesticides on ecosystems.
11. Develop, evaluate and integrate biological pest management strategies in farm systems.
12. Develop application methodologies to maximize efficacy and minimize off-target exposure of pest control agents.
13. Research global warming strategies to disrupt pest populations.

Group C

Tracey Hewitt, The Council on Food and Agricultural Resource Economics
David Eckhardt, USGS
Jill Bloom, USEPA-OPP
Mary Jane Letaw, NAS-NRC
Ben Coffman, USDA-ARS-WSL
Robert Lumsden, USDA-ARS-BCPDL
Pamela J. Rice, USDA-ARS-ECL

Facilitator: Douglas Boyette, USDA-ARS
Flip Chart Operator: John Teasdale, USDA-ARS
Recorder: Paul Moore, USDA-ARS-TFVRL

Breakout Session One: Brainstorm

1. Lack of alternatives to pesticides.
2. Reduced risk *vs*. reduced use.
3. Risk of alternatives.
4. Quantitate environmental costs.
5. Identify pesticides compatible with and useful in IPM.
6. Risks assessment *vs*. "mitigation technologies."
7. Need to define "risk."
8. Need for refined models:
   - Pesticide movement;
   - Systems/landscape; and
   - Pest population.
9. Economic consequences/ niches/interrelations of alternatives.
10. Trade-offs of risks and benefits of alternatives.
11. Concerns:
    - Risk assessment methodology;
    - Need for alternatives to pesticides;
    - Risk trade-offs; and
    - Risks of concern.
12. Focus on risks:
    - Environmental: soil, water, biota;
    - Health: human;
    - Economic: cost of production and tie to World trade;
    - Risk trade-offs: the alternative to pesticides has the array of risks associated with it and needs to be evaluated; and
    - Need for risk assessment methodology.

Breakout Session Two: Focusing Needs

1. Human health:
   - Food safety–Monitoring, analytic and technological;
   - Environment–Air, water & soil quality;
   - Legislation—*FQPA;*
   - Ethics; and
   - Endocrine disrupters.
2. Minor use:
   - Risk;
   - Minimize impact on non-target species;
   - Fate and transport;
   - Cost;
   - Toxic effects;
   - Industry/private/public development;
   - Organic farming; and
   - Human health.
3. Net economic returns:
   - Trade and global markets;
   - Systematic evaluation;
   - Legislation-unfunded mandates;
   - Organic farming;
   - Ethics;
   - Niche markets; and
   - Human health.
4. Common ground for risk perception:
   - Communication;
   - Education;
   - Ethics;
   - Agricultural and urban folks; and
   - Homeowner.
5. Biotechnology (transgenic) risk and evaluation:
   - Toxic effects;
   - Fate and transport;
   - Unknown risks (for non-transgenics as well);
   - Human health;
   - Resistance; and
   - Genetics.

6. Risk mitigation strategies and systems:
- Agricultural-urban interface;
- Fate and transport;
- Toxic;
- Minimization on non-targets; and
- Homeowners.
7. Science of the pest:
- Pest biology and ecology;
- Study of pest systems;
- Organic farming;
- Resistance;
- Genetics; and
- Exotic pests.
8. Safer alternative chemistries, with goal of lowering pesticide risk:
- Fate and transfer;
- Toxic effects;
- Industry/private/public;
- Human health;
- Minimization on targets; and
- Corn/beans, not basil.
9. Technology transfer:
- Model development and evaluation; and
- Organic farming.
10. Ecosystems:
- Fate and transport;
- Soil, air and water quality;
- Models and databases;
- Remediation;
- Analytic techniques; and
- Monitoring.
11. Biological control, low risk strategy:
- Beneficials; and
- Microbials.
12. Application technology:
- Sprays;
- Human exposure;
- Wildlife;
- Costs; and
- Beneficials.
13. "Global warming."

Also, the following list of factors, although not needs, must also be considered.

1. Maintain flexibility:
- Chemical alternatives:
  - Biological control agents, with a 10-15-year gap between research and implementation must be meaningful, practical, profitable and economical; and
  - Private *vs.* public research.
- Interim control agents;
- Long-term (risks in research);
  - Top-down management;
  - Promoting non-chemical, but toxicological, risk, economic, ecological, human health, and unknown systems;
- Political perceptions.
2. Problems:
- Cost of development of safe pesticides is high–reasons are public perception, regulation, sophisticated technology is expensive;
- Off-target dispersal;
- Mis-use;
- Pesticide resistance;
- Availability of products (lack of alternatives);
- Forces outside of USDA (responsibilities); balancing of missions that may conflict;
- What are the farmers' needs?; and
- Trade agreements.
3. Concerns:
- Funding category of chemical and non-chemical is not accurate;
- How to define pest management chemicals?;
- Measurement criteria: money, use, risk;
- Broad control *vs.* specific e.g., herbicides, better or not (it depends)?;
- Weed control is different from insect control;
- Urban/agricultural interface;
- Reduced risk *vs.* reduced usage;
- Public perception–Education;
- How integrated is IPM with other aspects than pests (nutrients, ecology, financial, toxicology, health)?;
- Pest resistance;
- Team research for systems approach;
- Scale of operation (small *vs.* large);
- Effects of new legislation;
- Performance and price–For pest control agents;
- EPA;
- Extension policy;
- What is ARS' role in promoting chemicals (e.g., Demilin, *B.t.*)?;
- Costs *vs.* benefits (how to determine these values?)
- How far to take it?
- Have we truly evaluated the effects of new bio-pesticides (transgenics)?;

- Should ARS evaluate impacts of new technologies on systems?; and
- Should ARS be the developer of new technologies or leave it to industry (in concert with academia and industry), or both?

Breakout Session Three: Final Ideas

1. Develop watershed models of environmental fate and non-target effects of pesticides.
2. Determine population biology and dynamics of pests.
3. Collaborate with other agencies:
- Identify critical grower needs;
- Determine economic impact of regulation;
- Support public policy decision-makers; and
- Develop alternatives for targeted products used in minor crops.
4. Develop alternatives (see alternatives list under B).

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Breakout Session One: Brainstorm

1. Pesticide Residues in Food.
2. Public concerns about air and water quality.
3. Lack of systematic approach for risk/benefit analysis for IPM issues.
4. Producers concerns' regarding economic products and alternatives.
5. Full-cost accounting for pesticide issues—effects on beneficials, non-targets, etc.
6. Registration system for pesticides based on science instead of emotion.
7. Concerns about what we "don't know" concerning pesticides.
8. Pesticide resistance issues--current products.
9. Genetically engineered crops and pesticide resistance.
10. Lack of viable economic alternatives for discontinued products.
11. Lack of strategies for predicting the need for alternatives.
12. Impact on non-target species and ecosystems.
13. Potential legal liabilities for not using pesticides.
14. Unrealistic tolerances for pests.
15. Lack of knowledge concerning basic biology of target pests.
16. Possible impact of *FQPA* on minor crops.
17. Pesticide compatibility with non-chemical tools.
18. Risk perception of pesticides *vs*. risk reality.
19. Lack of pesticides that can be used to guard the "public health" in case of emergencies.
20. Producers' fears about being out-competed in the global market.
21. Concerns about residues on imported crops.
22. Lack of cooperation among and between government and private agencies.
23. Need for consumer education on pesticide issues.
24. Include more social aspects in decision making process.
25. Lack of understanding of farming issues by the general public.
26. Need a set of standards and definitions of IPM in diverse cropping systems.
27. Better information on pesticide efficacy and damage thresholds.

Breakout Session Two: Focusing Needs

1. Pest biology and ecology.
2. Pesticide efficacy and economic thresholds.
3. Pesticide resistance including genetically modified organisms.
4. Holistic approach to IPM risk:benefit analysis.
5. Lack of lower-risk of alternatives, especially for minor crops.
6. Human exposure to pesticide residues (air, water, food).
7. Non-target species/ecosystems.
8. Sustained profits/global comparison (develop local market and value-added products).
9. IPM standards/definitions.
10. Exotic pest issues.
11. Risk mitigation.
12. Agricultural and urban interface.
13. Integration management options (organic farming practices).
14. Urban use of pesticides.
15. Biological control.

Breakout Session Three: Final Ideas

1. Prioritize current and future pest species, and conduct in-depth ecological studies on these species.
2. Probability of efficacy *vs.* rate of high-risk pesticides.
3. What are the mechanisms that facilitate development of pest resistance across various pest management strategies (chemical and non-chemical).
4. How do scales of analyses (organismal and spatial) affect IPM risk/benefit studies?
5. National analysis of cropping systems for effects of missing tools.
6. Increase support and validation for models of pesticide fate (including environmental toxicity of non-target organisms).
7. Identify IPM practice points and pesticide risk values for key cropping systems.
8. How do we predict the spread of pests at multiple scales (areas)?
9. Quantify benefits of pesticide risk mitigation strategies.
10. How do organic farming practices regulate pests?

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Breakout Session One: Brainstorm

1. Non-target effects:
- Birds, mammals, insects;
- Groundwater, wildlife issues (amphibian deformities);
- Carryover damage to other crops; and
- Endocrine disruption controversy.
2. Implement/transfer new technologies:
- Crop advisors from chemical companies, potential conflict of interest for crop advisors (who work for a chemical company!);
- Define roles of stakeholders;
- apparent decrease in extension and consequent problems;
- outreach and public education about pesticides; and
- Mitigation to prevent runoff and other environmental impacts.
3. Understanding exposure/defining & measuring
4. Unknown interactions/synergism of mixtures of pesticides
5. Persistence/environmental fate:

- Soil, water, air;
- Predictability; and
- Develop new monitoring tools.

6. Unfunded mandates.
7. Public concerns over food safety regarding pesticide use.
8. More effective pesticides and use of pesticides:
- New and better application technology;
- Better handling methods to improve applicator safety;
- Better/new formulations; and
- Smart-sprays.

9. Safety of alternative "new" chemistry pesticides.
10. Pest resistance from simple pesticide approach.
11. Over-reliance on single tools.
12. Linking seed companies with pesticide companies; e.g., transgenics.
13. Regulatory soup.
14. Big companies *vs.* small companies and "access" to markets and processes.
15. Fear of loss of independent farms.
16. Release of new products for testing–maintaining access to pesticide standards:
- Transgenics; and
- Radioactive samples and breakdown products.

17. Database availability:
- For safety, fate, effect; and
- Mode of action.

18. International issues–differences in registration, acceptance, standardization, NAFTA, biodiversity initiative.
19. Development of regional models for nutrient/pesticide runoff.
20. Difficulty of marketing pesticides for niche markets/minor crops, e.g., alga control for catfish production–little/no commercial interest.
21. Off-label/illegal use of pesticides.
22. Urban uses of pesticides:
- Lawn care; and
- Household

23. Interaction between pesticide/non-pesticide exposures under *FQPA*
24. Increased sensitivity of residue detection: If it can be detected, it must be hazardous.
25. "Cemo-phobia" policy *vs.* risk-driven policy.
26. Increasing use and consequent over-reliance on herbicides, but no concomitant increase in funding for research on alternatives.
27. Defining low-risk pesticides.
28. Chemical:
- Low mammalian toxicity;
- Selective;
- Short residual, quick breakdown;
- Low risk to food supply;
- Little movement into environment;
- Well-defined interactions with other pesticides;
- Knowledge of long-term effects on environment, ability to monitor; and
- Predictability: Efficacy, environmental impact.

29. Biological:
- Low mammalian toxicity;
- Appropriate host range;
- Slow breakdown, long residual;
- Low risk to food supply;
- Well-defined interactions with other pesticides;
- Controlled movement into environment;
- No non-target toxic metabolites; and
- Knowledge of long-term effects on environment and ability to monitor.

30. Predictability: Efficacy, environmental impact.

Breakout Session Two: Focusing Needs

1. Environmental fate.
2. Pesticide alternatives.
3. Non-target.
4. Pesticide risk reduction.
5. Pest crop/system biology and ecology.
6. Minor crops/management alternatives.
7. Sustainable agriculture.
8. Resistance management.
9. Exposure risk (long- and short-term).
10. Food residue analysis.

Breakout Session Three: Final Ideas

1. Environmental fate:
- How can we reliably predict the fate and behavior of pesticides in the environment?
- How do new patterns of use of existing pesticides affect fate?
- What is the fate of new chemicals in the environment?

2. Pesticide alternatives:

- How can we discover, develop, adopt, evaluate, and incorporate effective alternative pest management practices?

3. Non-target:
- How can we minimize the adverse impacts of agricultural pest control strategies on non-target organisms?

4. Pesticide risk reduction.
5. Pest/crop/system biology and ecology:
- How can we determine and exploit pest life history strategies for effective control?
- Determine relevant interactions among pests, cropping systems, and components.

6. Minor crops:
- How can we ensure safe and profitable production of minor crops?

7. Sustainable agriculture
- What is the role of pesticides in sustainable systems?

8. Resistance management:
- Determine and incorporate appropriate resistance management strategies for use with pesticides and alternatives;
- Evaluate the impact of engineered pest- and herbicide-resistant crops; and
- Determine strategies to prevent resistance development.

9. Exposure risk:
- How do we optimize target acquisition and minimize unintended effects?
  - Improve formulation and application to minimize pesticide quantities without loss of efficacy;
  - Develop and validate mitigation techniques and determine economic consequences; and
  - Quantify human and non-target exposure.

10. Food residue analysis
- What is the impact of changing production, storage, and transport systems on pesticide residues in food commodities?

Group F

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Breakout Session One: Brainstorm
Concern: Site specific information
Problems:

1. Reducing farmer dependence on pesticides, especially pesticides with most risk (see *FQPA*), assessments based on health risk, benefit assessments not now used.
2. Gradually introduce lower risk pesticides (reduced risk or safer).
3. Lack of choice of lower risk pesticides, need alternatives.
4. Private industry can't afford (economic and risks) doing minor use pesticide registrations.
5. Soil persistence.
6. Toxicity of compounds and metabolites.
7. Lack of databases (chronic long term & acute short-term effects).
8. Role of application technology (environmental and personal contamination) and misapplication.
9. Test systems (how do you do a 30-year-study in 24 months), lack of screening systems.
10. Suboptimal use of personal protection equipment.
11. Development of closed systems to minimize exposure.
12. What is risk assessment? (risks *vs.* benefits).

13. Lack of public awareness of positive aspects of pesticides, how do you move perception away from harmful effects of pesticides?
14. Documentation of harmful effects of pesticides.
15. Difficult to limit pesticide use based on what we know (what are the harmful effects, etc.).
16. Increased number of individuals watching over everyone doing the studies (increased bureaucracy and increased resources), GLP and how it's defined Effectiveness of GLP and practices related to it.
17. Genetically altered crops (pesticide resistant) that will allow increased or specific pesticide use (over-reliance of the crop).
18. Resistance management of pesticides before resistance occurs.
19. How does our current pesticide use practices/policies affect global markets (if farmer can't sell product in overseas market, how will the technology be used?)
20. Making labels more user friendly for all users.
21. Homeowner/urban use may be more problematic.

Consensus:
1. How do we test the long-term effect of pesticides within a few years?
2. Lack of database (chronic long term & acute short-term effects).
3. The new *FQPA* guidelines changed the way pesticides are evaluated The only significant factor is their potential impact on health, regardless of their benefits to society. Under such a system, the conclusion is that all chemical pest control cause a relative health risk. Therefore, all chemical control should ultimately be banned. This is, in my opinion, one of the biggest challenges facing agriculture.

Breakout Session Two: Focusing Needs
1. Problems.
- Reducing farmers' dependence on pesticides, particularly high-risk pesticides;
- *FQPA*: Assessment based on health, benefits are not taken into account;
- Gradually introduce lower-risk pesticides;
- Need for alternative pesticides;
- Lack of available compounds in minor crops;
- Private industry cannot afford developing compounds for minor crops, especially cost of registration;
- Soil persistence;
- Toxicity of compound and metabolites; and
- Lack of database, acute *vs.* chronic information.
- Role of application technology:
  - Misapplication;
  - Environmental and personal contamination; and
  - Lack of test/screening system for long-term effects

Breakout Session Three: Final Ideas
1. Role of application technology.
2. Suboptimal use of personal protection.
3. Development of closed systems.
4. What is risk assessment?
5. Lack of public awareness of positive aspects.
6. Documentation of harmful effects.
7. Difficulty in reducing pesticide use based on what we know.
8. GLP constraints.
9. Genetically altered crops: over-reliance.
10. Resistance management.
11. Global market concerns.
12. Home use-labels, application.

Group G

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Breakout Session One: Brainstorm &
Breakout Session Two: Focusing Needs

1. Pesticide Characteristics and Application.

- Ability to monitor use levels;
- Lower contamination potential:
  - Mobility (soil, air, water);
  - *No* bioaccumulation;
  - Lower toxicity (raise LD_{50});
  - *No* residues beyond efficacy;
  - Better knowledge of *transformation products;* and
  - Low potential for development of resistance.
- Physical "placement" and formulation:
  - GPS/GIS coupled with precision and prescription application;
- Control of off-site movement:
  - Criteria for buffer zones related to crop sensitivity.

2. Environmental and Human Risk Assessment

- Laboratory *vs.* field data:
  - Extrapolations?
  - Not the real world.
- Use of models–validity–choices?
  - Problem: Not adequate training
- Improved *pesticide detection.*
- Home-owner use/misuses:
  - Labeling problems.
- Ecosystem-level effects (population dynamics);
- Negative impacts of *substitutes;*
- Genetically Engineered Organisms:
  - Tolerance to pesticides; and
  - Alleluchemicals.
- Pest-Pest Interactions;

3. Education

- Technology Transfer:
  - Where is bottleneck?
- Public Education:
  - Risks=?
  - IPM; and
  - General Pest Impacts.
- Public Health:
  - Relative to *food production systems*; and
  - Perceptions/reality.

4. Regulatory Issues:

- Support to meet *FQPA;*
- Scale (space and time):
  - Area-wide approach;
  - State boundary issues (ecosystem scale); and
  - Eradication and quarantine criteria (lower pest movement);
- Compatibility of pesticides:
  - With other pesticides; and
  - With IPM goals.
- Grower/farmer perspective:
  - Ease of use; and
  - Problem of high specialization and high training needed.
- Homeowner use–*better labels.*
- Genetic engineering.

Breakout Session Three: Final Ideas

Proposed Definition of Reduced Risk:
Minimize misplacement, accumulation and transformation of pesticides so that their use will not result in adverse environmental effects nor adversely affect human health, development, and reproduction.

1. Lower contamination potential

- Improving placement.
- Establishing dosage.
- Develop information and methodology to minimize contamination potential (e.g. reduce mobility, use precision agriculture, new formulations, better knowledge transportation properties).

2. IPM-alternative control

- Less toxic pesticides.
- Ecologically based alternatives.

- Discover and develop IPM components for integration in area-wide pest management systems.

3. Pest-pest host interactions
- Investigate biological interactions among multiple pest and host complexes correlated to pest management systems
4. Lab *vs.* field data
- Develop capability to use lab data and to evaluate potential field effects (e.g. resistance monitoring, non-target resource effects, multiple chemical effects, multiple application effects)
5. Ecosystem-level effects
- Initiate long term, interdisciplinary studies on ecosystem health and stability in agricultural and/or natural resource areas
6. Detection and monitoring abilities
- Discover and improve sensitivity levels, methodology, detectionability of chemicals with potential to impact environment, and to enable use-monitoring
7. *FQPA* Support.
- Conduct research to support *FQPA*, particularly in areas of IR-4 including livestock and poultry production.
- Collaboration between IR-4 research and ARS human nutrition research.
8. Genetic engineering.
- Conduct basic research in genetic engineering to develop genetically altered organisms as means of reducing pesticide use and to monitor ecological impacts.
- Technology transfer.
- Develop and improve mechanisms to transfer information to growers, homeowners, industry, and other agencies.
9. Modeling and Support.
- Develop or enhance existing models for use in management.
- Support models and databases (e.g. ARS-PPD) and data sets to be used for calibration.

Group H

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Breakout Session One: Brainstorm

1. Pesticide metabolites Lack of information on environmental fate.
2. Long-term effects of pesticide use:
- Need more information; and
- Human, animals, transgenic crops, weed population dynamics.
3. Improvements in analytical detection:
- What do the results mean?
- MDL Health advisory level risk.
4. Collaboration between scientists and working groups multi –disciplinary:
- Producers may be slow to adopt new and lower-risk technology of pesticides; and
- Incentives may be needed.
5. Information on foliar washoff of herbicides and pesticide plant residue (cover crops) interaction.
6. Need information on regional effects on pesticide use and fate:
- Clarification of pesticide use in IPM.
7. Pesticide-soil-nutrient interactions more information.
8. Need to focus on promising areas for biological control agents:
- Collaboration with industry; and
- Consider developing biological control products for the homeowner.

Breakout Session Two: Focusing Needs

1. Environmental fate of newer pesticides and metabolites (processes i.e., persistence, leaching, volatilization) coupled with modeling and agronomic changes.
2. Lack of information/databases available to multiple users–formalize information technology transfer.
3. Alternatives to potentially discontinued pesticides not presently available ("*FQPA* is a four-letter word").
4. Full cost accounting for pesticide impacts (water, risk management, incentives to adopt practices).
5. Risk mitigation strategies.
6. Non-target effects at low concentrations: Long-term chronic effects, resistance, endocrine disruption.
7. Urban users of pesticides–relative environmental impact compared to agronomic use.
8. Need to focus on areas for biological aspects–develop commercial products for urban use.
9. Environmental impact scaling issues–from guacomol (10^{-26}) to universe.

Breakout Session Three: Final Ideas

1. Technological issues:
- Apply existing methodologies to new/newer pesticide management systems;
- Develop better analytical methodology for detection; and
- Use models to better define research gaps.
2. Cooperation:
- Establish interagency workgroups at scientific society level to exchange information and exchange databases (i.e., ARS, EPA, USGS, Extension, FDA).
3. Alternatives:
- Develop alternatives to conventional chemicals likely to be lost to *FQPA* or other mandates (i.e., biological control and IPM).
4. Economics:
- Must incorporate economics;
5. Must incorporate full risk assessment;
- Probabilistic modeling; and
- Management systems comparison.
6. Risk mitigation:
- Regionalized risk mitigation strategies (i.e., buffer strips, cover crops, application technology and formulation, etc.); and
- Demonstrated efficacy (i.e., monitoring) of the strategy, tail-water filtration.
7. Communication:
- Establishment of research dialogue with ecologists and toxicologists;
- Development of research projects on long-term, chronic effects/exposure; and
- Development of techniques and criteria to determine long-term chronic effects.
8. Urban needs:
- Urban watershed monitoring to determine loads and contribution to impact; and
- Develop urban pesticide-use strategy to mitigate the impact in the ecosystem.
9. Collaboration:
- Collaborate with industry and user groups to determine promising areas for biological pest control; and
- Find, produce and formulate candidate biological control agents.
9. Investigate the application of information obtained at #1 to scale enlargement

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Agenda
Reducing Pesticide Risk Workshop

Tuesday, December 2

8:00-9:00	Registration
9:00	Workshop Procedures And Norms, Del Delfosse, Co-Moderator
9:15	Welcome, Dr. Darwin Murrell, USDA-ARS Deputy Administrator
9:30	Introductory Remarks, Keith Pitts, Special Assistant To Deputy Secretary Of Agriculture Richard Rominger
9:45-10:00	Charge To Workshop Participants, Michael Jawson, Co-Moderator
10:00-10:30	Break
10:30-11:15	Overview Presentation: "The ARS Program In Pest Management: A Perspective", Robert Faust
11:15-12:45	Breakout Groups Brainstorm The Question: "What Are The Concerns, Problems, Issues With Pesticide Use In US Agriculture?"
12:45-1:45	Lunch
1:45-3:15	Customer Group Presentations And Discussion • Producers • Industry • Regulatory/Action Agencies
3:15-3:45	Break
3:45-5:15	Customer Group Presentations And Discussion (Continued) • Other Federal Groups • Sustainable Agriculture • Environmental Interests
5:30	Return To Hotels
6:30	Dinner At 94th Aerosquadron

Wednesday, December 3

8:30-10:00	Reports Of Breakout Groups By ARS Facilitators
10:00-10:30	Break
10:30-12:30	Poster Presentations And Discussions
12:30-1:30	Lunch

1:30-3:30	Breakout Groups Meet To Focus Issues
3:00-3:30	Break
3:00-5:00	Breakout Groups Meet To Define Research Questions From Focused Issues
5:00	Return To Hotels
Evening	Dinner On Own

Thursday, December 4

8:30-10:00 Reports Of Breakout Groups By ARS Facilitators

10:00-10:15 Break

10:45-11:45 Panel Discussions By Members Of Each Customer Group: Impressions, Critique Of What Has Been Accomplished, Future Procedures.

- Producers
- Industry
- Regulatory/Action Agencies
- Other Federal Groups
- Sustainable Agriculture
- Environmental Interests

11:45-12:00 Workshop Summary (Nancy Ragsdale)

12:00 Workshop Ends–Lunch On Own

Chapter Three: Research Abstracts

Research From the Field Scientists at the Agricultural Research Service

on Reducing Pesticide Risk

The research abstracts are arranged alphabetically, by author.

1 Development of Biorational Insecticides against the Whitefly, *Bemisia argentifolii*, In Cotton

D.H. Akey and T.J. Henneberry
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The silverleaf whitefly, a serious pest of cotton, melons, other curcubits, tomatoes, alfalfa, and many other foods and ornamental crops, can be suppressed in Arizona by use of Integrated Pest Management (IPM). A key element in this plan is the use of two insect growth regulators (IGRs). These IGRs, buprofezin (Applaudtm) and pyriproxyfen (Knacktm) belong to a broader, diverse, group of environmentally friendly pesticides known as " biorationals". Biorationals include " ... any type of insecticide active against pest populations but relatively innocuous to non-target organisms, and therefore non-destructive to biological control" (Stansly *et al.* 1995). "Biorational" is now considered to be an obsolete term by the Environmental Protection Agency (EPA) because of vagueness, that required legally defined terms that conflicted with it. However, it remains a very useful term for agricultural workers (Ware, 1994 and 1996). A component of IPM is insecticide resistance management (IRM). It has a goal of preventing the target and other pests from losing their susceptibility to particular insecticides. Strategies for this include rotating classes of insecticides, using labeled rates, and limiting the number of applications of insecticides in one class. The more classes of pesticides available usually requires more and different modes of pesticide detoxification by the insects. Biorationals contribute greatly to this by having unique detoxification modes.

To be successful in IPM and IRM, we need more biorational agents that are efficacious and can be applied efficiently. Our work reported here details efforts to achieve that. This cotton season, we evaluated a neem product (the azadirachtin Bollwhip™), microbial agents *Beauveria bassiana* (two brands, Mycotrol™ and Naturalis-L™) and *Paecilomyces fumosoroseus* (PFR-97™), and a sugar ester.

Azadirachtin (Bollwhip™) was effective at controlling silverleaf whiteflies at three rates tested. The best control was effective against small nymphs as reflected in the lower numbers of larger nymphs, especially near the end of the season in late August and early September. Acyl sugar was almost as effective as azadirachtin was in controlling eggs. It appeared to have mean numbers of larger nymphs similar to the average of the three rates of azadirachtin. A good comparison for determining efficacy of both azadirachtin and acyl sugar is to compare them with the efficacy of the conventional insecticide, endosulfan. The endosulfan treatments held the nymphal stages to means of about two nymphs, however the two biorational agents appear to have means of about four nymphs. This is excellent control and produced open bolls with non-sticky cotton.

The microbial biorationals (entomopathogenic fungi) were likewise effective but appeared to have slightly less efficacy for controlling silverleaf whiteflies eggs. The control of nymphs appeared to be similar for both formulations of *B. bassiana* and were slightly more effective and *P. fumosoroseus*. A

"best agricultural practice" regime consisted of only five sprays for the entire season against silverleaf whitefly. The numbers of immatures were higher in this treatment and in the other treatments; nevertheless, control was still sufficient to produce clean, non-sticky cotton. An untreated block control which was solid planted and almost and acre in size was a better comparison as an untreated check than the embedded random water-treated control. Cotton in the block control was very sticky by the first week in September, both lint and leaves. This work to develop and learn how to use these biorational pesticides was productive and encouraging.

2 Balancing Eco-Sociological Impacts And Herbicide Use In Nonindigenous Aquatic Pest Eradication Programs

Lars W. J. Anderson[1] and Nathan Dechoretz[2]
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Decisions on optimal management strategies for controlling pest generally hinge on weighing impacts caused by the target pest against costs and adverse consequences of the various control methods. This "balance" is generally made with an assumption the target species will always be present and be kept at a "non-problematic" level of infestation. However, when the target is pest is a "new" exotic or an exotic with small geographical distribution, these assumptions may not be appropriate nor result in the most desirable management practices. Management costs and herbicide usage can be reduced through a well executed eradication program that includes: (1) front-end public education and input; (2) early detection; (3) removal, and (4) monitoring.

The California hydrilla eradication program has required about $30 million over the past 20 years and has to date preserved vitally important water resources including the Sacramento-San Joaquin Delta, source waters for over 22 million people and much of the irrigated agriculture in the state. Most of the state's $25 billion agricultural economy depends upon adequate and timely access to irrigation water. The program, which employs chemical, mechanical and biological approaches has stopped actively growing populations of hydrilla in every infestation and thereby eliminated new dispersal sources. Opting for a "maintenance-management" approach would have resulted in hundreds of new source sites, infestation of the Delta, loss of $100 million annual revenues for 43, 000 Clear Lake. This in turn would have required continuing inputs of many thousands of pounds of copper-based and organic herbicides into the states waters each year.

Regionally, a "quick-fix" strategy would have led to the transport of hydrilla to neighboring states (OR, WA, AZ, NV). The lesson from the hydrilla experience is clear when comparing alternative approaches taken in Florida, Texas and Alabama, where, taken together, "maintenance costs" exceed $15 to 20 million annually and where dispersal continues. Other nonindigenous species, including the zebra mussel are already "knocking on the door" in the West. It will be imperative to implement eradication plans for this and other new invaders as an effective way to minimize dependence on pesticide inputs to aquatic resources.

3 Insect Pest Management For Stored Grain And Processed Food Warehouses

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The Biological Research Unit (BRU) conducts mission-oriented entomological research with stored-product insects and is one of three research units at the U. S. Grain Marketing and Production Research Center, Manhattan, Kansas. The primary responsibility of this

group is to develop ecologically-based technologies to replace or reduce the use of traditional pesticides. Multi-disciplinary teams conduct research on: (1) ecology, population dynamics, and behavior of pest and beneficial insects leading to the development of expert systems for pest management in farm and commercial storages; (2) pest management systems that utilize parasites, predators, and pathogens to control stored product insects; (3) novel control techniques based on a knowledge of insect genetics, physiology, biochemistry, toxicology, and molecular biology; and (4) pest management strategies focusing on the efficient use of pesticides, aeration, monitoring techniques, and resistance management.

4 Weed Control With Bioherbicides And Natural Products

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As public pressures increase for reducing chemical inputs in agricultural and horticultural production systems, researchers are challenged to develop safe, effective, low-risk weed management strategies that are cost-effective and offer chemical-like levels of activity. The use of indigenous plant pathogenic fungi, bacteria, and certain of their natural products such as phytotoxins and antibiotics provides an environmentally responsible approach for controlling weeds in agronomic crops as well as weeds which were formerly controlled by methyl bromide in some horticultural systems.

Numerous indigenous plant pathogens such as *Alternaria*, *Colletotrichum*, *Fusarium*, *Actinomyces*, *Pseudomonas*, and *Xanthomonas* spp. have been isolated from several weed species including hemp sesbania (*Sesbania exaltata*), common cocklebur (*Xanthium strumarium*), coffee senna (*Senna occidentalis*), sicklepod *(Cassia obtusifolia*), showy crotalaria (*Crotalaria spectabilis*), spurred anoda (*Anoda cristata*), prickly sida (*Sida spinosa*), velvetleaf (*Abutilon theophrasti*), jimsonweed *(Datura stramonium*), morning glories (*Ipomoea* spp.), and Texas gourd (*Cucurbita texana*), and phytotoxins such as AAL-toxin, moniliformin, and tagetitoxin have been discovered and evaluated as bioherbicides by researchers in the SWSRU. Through formulation and production technology innovations, the performance of many of these biological herbicides have been improved to the level of recommended chemical herbicides.

5 Developing Precision-Targeted Reduced-Risk IPM Strategies For Department Of Defense Pests And Disease Vectors

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Under the Strategic Environmental Research & Development Program, USDA-ARS-CMAVE is developing a GIS-based, versatile system to reduce pesticide use through the use of precision targeting based on standardized monitoring procedures for DoD pests and disease vectors. Spatial statistics is used to assess pest & pathogen distributions that result in GIS themes describing risks (probabilities of exceeding acceptable thresholds) in the absence of interventions. Examples will be given for cockroaches in food service facilities, pharaoh ants in hospitals and living quarters, and mosquitoes and dengue fever in scenarios representing DoD deployments. Impact of interventions is documented spatially for pharaoh ants, and the resultant reduction in pesticide use is documented.

6 Innovative Research And Technologies To Protect Agricultural Products From Pests And Disease

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The ARS Plant Protection Research Unit at Ithaca, NY, develops new innovative methods to protect crops from pest damage and develops crop production systems that improve crop yields. Our goals are to devise practical pest control methods that minimize or eliminate chemical pesticides while maintaining pest damage below economic thresholds, and to develop new cropping systems that select for beneficial soil organisms. Our specific objectives are to develop economical, environmentally compatible strategies for long-term management of a wide variety of pests and to develop sustainable cropping systems. To accomplish these objectives, we conduct research in host plant resistance, biological control by fungal pathogens and antagonists of pests, interference with pest life cycles, development of biopesticides and crop rotations. Our culture collection of fungal pathogens of insect and nematode pests is a unique resource that supports development of target-selective, environmentally benign biocontrol agents and biopesticides. Key commodities are cereal grains, vegetable, and forage crops (potatoes, crucifers, alfalfa) but results are applicable to crops in general.

7 Sustainable Integrated Weed Management Systems For Cotton, Soybeans, And Other Crops

Charles T. Bryson, Krishna Reddy, and Kevin Vaughn
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Scientists at the Southern Weed Science Research Unit (SWSRU) are developing sustainable crop production systems that incorporate various cultural practices, crop rotations, herbicide-resistant crops, and herbicide application technologies for maintaining adequate weed control while lowering costs and reliance on herbicides. One strategy is to improve weed control by increasing plant residue coverage of soil by reduced-tillage and cover crops. Results have shown that plant residues prevent seed germination and establishment, thus reducing need for preemergence and some postemergence herbicide applications. Narrow-row crop spacing provides canopy closure more rapidly and inhibits weed germination and growth more effectively than in conventional wide-row spacing. Herbicide-resistant weeds have developed virtually for every class of herbicide and in many cropping systems. SWSRU scientists are studying mechanisms of resistance in order to better understand how to manage or prevent herbicide-resistance.

Results of this and other research have already demonstrated that double-cropping and crop and herbicide rotations reduce development of herbicide-resistant weeds. Crop resistance to herbicides is being developed in a number of crops. Several unknown aspects of managing these crops which SWSRU scientists are studying include: (a) potential for herbicide-resistant weeds be promoted in such systems because of overuse of a herbicide or a resistant gene be transferred to weedy relatives; (b) long-term effects on weed populations; and (c) if additional herbicides will be required for effective weed control.

SWSRU scientists are investigating aspects of precision agriculture related to weed control. SWSRU scientists are also heavily involved in the MSEA Project evaluating effects of hooded-sensor sprayers on weed density and population shifts compared to conventional production systems in cotton and soybeans. By evaluating herbicide formulations, diluents, and surfactants, SWSRU scientists are developing best management practices for

more effective and efficient weed control and to increase the spectrum of herbicide efficacy. All SWSRU research includes both indigenous and non-indigenous (exotic) invasive weeds in cotton, soybeans and other crops.

8 Development And Evaluation Of Integrated Weed Management Systems: Environmental, Production, And Biological Interactions

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More than 95% of the of the corn and soybeans in the Midwest are treated with one or more herbicides each year. Consequently, more than 80% of total pesticide use in this region is herbicide. Thus, any serious attempt to reduce pesticide use in the Midwest must focus on weed management. Currently, there is much interest in development of integrated weed control systems in which greater emphasis is placed on controlling off-site movement of herbicides through combinations of agricultural management practices, biological controls, and new chemistries, which offer high efficacy at very low application rates. The overall goal of this project is to develop improved management practices to minimize the adverse impacts of weeds in cropping systems and reduce the environmental impacts of herbicides.

This goal is being approached through developing a better understanding of herbicide fate and movement in alternative cropping systems and integrating weed population information into weed management systems. Specific objectives include: a) determine the impacts of weed management practices (chemical and nonchemical) on water quality, soil quality, and weed populations; b) develop practices to reduce environmental impacts of weed control by integrating knowledge of weed population biology and herbicide behavior into new farming practices; and c) integrate research findings to develop decision aids for implementation of new weed management practices. Farmers depend heavily on herbicides for weed control in corn and soybean production because few other choices are available. Alternative weed management strategies must be designed to provide effective weed control, while reducing off-site losses of sediment or herbicide into water resources. Producers must be provided with improved knowledge of weed populations and integrate this knowledge with all available weed management options to develop more effective and environmentally benign weed management systems.

9 Corn Rootworm Area-Wide Management With Semiochemical Insecticide-Baits In South Dakota: A Model System For Development Of GIS To Track Insect Populations, Corn Phenology, And Pesticide Use

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Western and northern corn rootworms are among the most economically and environmentally important insect pests of corn production systems throughout the Corn Belt. Annually, 20 to 25 million acres of corn are treated with soil insecticides to protect the crop from larval feeding damage. This represents the single largest use of insecticide in the United States, with most of the applications made without knowledge of corn rootworm population levels or actual need for application. Concerns over prophylactic insecticide applications resulted in the development of semiochemical insecticide-baits by ARS and state agricultural experiment station scientists which would target economically threatening populations of corn rootworm adults.

Beginning in 1997 these baits were used in five producer scale area-wide management sites across the U.S. in an attempt to provide a more efficacious IPM program for corn rootworm. One of these five sites, a 16 sq.

mile area in Brookings Co., SD, is being used as a model area-wide management site to evaluate new bait technologies and monitoring/assessment methods. GIS technology is being used for organizing and storing data, monitoring and management of resources and activities, and as a modeling and research tool to address the needs of area-wide management. Information is being gathered on corn rootworm population trends throughout the area, pesticide use patterns (including semiochemical insecticide-baits), and changes in plant phenology/morphology as related to crop management and insect feeding. The data gathered will be used to develop models for predicted outcomes for corn rootworm management tactics over broad geographic areas and should lead to improved, environmentally sensitive corn management.

10 Glyphosate-Surfactant-Carrier Systems For *Erythroxylum* sp. Control

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Glyphosate is currently used to control illicit coca (*Erythroxylum* sp.), source plant of cocaine. Inconsistent results, however, led us to conduct field studies (1995-97) intended to increase glyphosate activity and consistency. The herbicide was applied at three rates (1.1, 2.2, and 4.4 kg/ha), in water or paraffinic oil as carrier, to the two major drug crop species, *E. coca* var. *coca* (coca) and *E. novogranatense* var. *novogranatense* (novo). Surfactants were different for the two carriers. Novo was easier to control than coca. For both species, control was slightly better at 4.4 kg/ha than 2.2 kg/ha, and least for 1.1 kg/ha. Surfactants and paraffinic oil carrier increased glyphosate activity, but in species-dependent ways. Paraffinic oil increased the activity of glyphosate on coca but not on novo. Surfactant, in water, generally increased the efficacy of glyphosate efficacy on novo. The differences between surfactants were greatest at a glyphosate rate of 1.1 kg/ha. Two surfactants, in water, were superior, [paraffin-based petroleum oil + sorbitan ester-based emulsifiers + polyalkyleneoxide-modified heptamethyltrisiloxane] and [polyethoxylated alkyl amines (C_8-C_{18}) + alkyl polyoxyethylene glycols + organic acids], improving herbicide performance such that coca and novo control did not differ for either 1.1 or 4.4 kg/ha.

11 Formulation, Production, And Shelf Life Of Granular Bioherbicides

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Improved formulation technology is needed to preserve the viability of fungal weed pathogens in products with commercial potential. Shelf life of granules containing matrix-encapsulated inoculum of *Fusarium oxysporum*, a pathogen of coca, and *Colletotrichum truncatum*, a pathogen of hemp sesbania exceeded one year at 25°C. Factors that promoted increased shelf life were water activity (aW) of the product and choice of fungal inoculum, such as naturally-stable chlamydospores of *F. oxysporum* or microsclerotia of *C. truncatum*. Additionally, encapsulation in a matrix protected the inoculum throughout processing and storage. The matrix chosen was composed of wheat flour and kaolin ('Pesta'). The wheat flour component provided nutrients for proliferation of the fungal bioherbicide agent. Pesta granule production is now in the pilot plant stage using twin-screw extrusion and fluid bed drying equipment.

12 Using Products Of Nature To Manage Pests

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Natural products offer a vast, virtually untapped reservoir of chemical compounds with many potential uses. One of these uses is in agriculture to manage pests with less risk than with synthetic compounds that are toxicologically and environmentally undesirable. The mission of the Natural Products Utilization Research Unit, located within the National Center for the Development of Natural Products (NCDNP) at Oxford, MS is to discover natural products for use in agricultural pest management, with emphasis on pest management agents derived from plants. Discovery efforts are focused on products for agricultural sectors that the agrochemical industry has little interest in, such as horticultural crops and aquaculture. The NCDNP offers ARS the opportunity to leverage and focus its resources in the area of natural products for agriculture. Finding the appropriate use for a natural product is extremely difficult without a broad array of scientists who can search for many potential uses. Many of the compounds that NCDNP have isolated could be valuable agricultural chemicals. The assets of both ARS and NCDNP are leveraged to greatly increase the probability of discoveries that will impact agriculture. Furthermore, ARS expertise is useful in the development of pharmaceuticals from plant sources, creating alternative crops for small farms. Examples of ongoing research, such as discovery of selective blue-green algicides for the aquaculture industry will be discussed.

13 Implementing Biology In Pest Management Leads To Right-Input Agriculture

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The low-input *vs.* high-input dichotomy in pest management may not reflect the manner in which most field-crop producers make decisions. Within the month before and after crop sowing, philosophical dilemmas regarding the ethics of pest control technologies likely are only of secondary importance to most producers. Of paramount importance for decisions made by modern producers are time restrictions tempered by financial constraints. Pest research efforts may be more productive if they focus on facilitating timely and biologically based management decisions, irrespective of whether management tactics involve biological, chemical, cultural, or physical control. A simple example involves postplant control of green foxtail (*Setaria viridis*). Control of this weedy grass in row crops is maximized if: (a) rotary hoeing is implemented at 30% predicted foxtail emergence; (b) interrow cultivation is implemented at 60% predicted emergence; (c) preemergence herbicides (e.g., metolachlor) are applied before 10% predicted emergence; and (d) non-residual postemergence herbicides (e.g., nicosulfuron) are applied when emergence is 100% and seedling height is predicted to be between 5-10 cm.

Control of this weed can be optimized when rotary hoeing occurs at 30% predicted foxtail emergence coupled with application of one-tenth labeled rate of preemergence herbicide (e.g., acetachlor). With this strategy control is better and cheaper than that with application of full herbicide rates. Implementing weed management on a biological basis makes it less risky, more profitable, and perhaps more acceptable to a skeptical public.

14 Atmospheric And Surface Interactions In The Fate And Transport Of Agrochemicals Within The Chesapeake Bay Watershed

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The fate and transport of agrochemicals are a function of the compound structure, the molecular environment, associated partition coefficients and meteorological factors. The purpose of this project is to elucidate the various processes and determine the rates and significance of each that affect the fate and transport of agrochemicals of significance to the Chesapeake Bay watershed. Conformational and configurational changes of some agrochemicals have been shown to influence degradation and partitioning within the environment. *Henry's Law* constants have been measured in relation to critical environmental parameters including temperature, salinity, and pH. Molecular and physical properties of agrochemicals combined with environmental conditions determine their persistence and ultimate fate within an ecosystem. However, actual measurements of agrochemicals in environmental samples often illuminates a key factor controlling the partitioning of these compounds into different environmental matrices. For example, enrichment of agrochemicals in fog water is often greater than would be predicted from the *Henry's Law* constant of the compound. High levels of dissolved organic matter and small droplet size during the fog event can cause increased concentrations over expected values. While runoff from agricultural fields is an important route for agrochemicals to move into surface waters, measurements of air and rain concentrations have shown that atmospheric deposition is an important source of these chemicals to the Chesapeake Bay.

15 Investigation Of The Allelopathic Effect Of Corn Spurry (*Spergula arvensis L.*) On Cole Crops And English Pea

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Studies were initiated to investigate severe growth inhibition observed when some vegetable crops were infested with corn spurry (*Spergula arvensis*). Interference by a natural population of the weed reduced the shoot fresh weights of English pea (*Pisum sativum*) and collard (*Brassica oleracea L.)* by 93 and 72 %, respectively. In a greenhouse experiment where light competition by corn spurry was prevented, broccoli (*B. oleracea L.*) shoot weights were reduced by corn spurry, but pea weights were not different from the controls. Homogenized corn spurry shoot tissue incorporated into a greenhouse potting medium inhibited the growth of both species, and a concentration effect was observed. Sequential hexane, dichloromethane, methanol, and 50 % aqueous methanol extracts of corn spurry root and shoot tissue were tested for inhibitory activity using millet seed germination and broccoli seedling growth bioassays. Dichloromethane, methanol and aqueous methanol shoot extracts were inhibitory to broccoli; whereas, all shoot extracts inhibited millet germination. Shoot extracts were more inhibitory than root extracts. Further fractionation of the inhibitors using a combination of reversed-phase sephadex LH-20 and silicic acid column chromatographic procedures showed that a major portion of the millet germination inhibition was due to sucrose esters (SE). Preliminary characterization of the esters showed that there were four different SE groups. The major groups contained either octanoic or dodecanoicacid along with butanoic and pentanoic acids. All groups inhibited seed germination, and some groups were active at concentrations lower than 20 ppm. This is the first report of the SE class of defense chemicals in plant species outside of the Solanaceae family.

16 Environmental Fate Of Herbicides In Tropical Soils

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American efforts to combat cocaine and other illegal drugs has, as one major goal, acreage reduction of coca (*Erythroxylum* sp.). Currently, herbicide application is the only practical means to achieve this. Besides efficacy, the assurance of safety to humans and the environment is critical from both the U.S and producer country's standpoints. A large database exists for environmental fate of the most effective coca herbicides, but this is based almost entirely on behavior under temperate-zone conditions; illicit coca is grown under tropical and subtropical conditions (mainly in Bolivia, Peru, and Colombia), lending concern that existing information may inadequately describe pesticide fate there. In ARS research to assist the U.S. State Department and cooperating Latin American countries in coca eradication programs, coca herbicide fate research was therefore conducted under tropical field situations. This was done at a secure U.S. field site as well as on illicit coca fields in Peru and Panama. Soil was analyzed to determine herbicide persistence and leaching; when possible, surface water and groundwater was also monitored for contamination. Residual phytotoxicity was determined by periodically replanting up to seven crops (U.S.) or by observing the effect of aerially-applied herbicide on food crop survival and on natural revegetation. Finally, laboratory testing of persistence/metabolism and leaching was conducted.

Among the major conclusions of this series of investigations were: (a) herbicides dissipated much more rapidly under tropical conditions than under typical U.S. temperate-zone regimes, (b) leaching risk was reduced because of this faster breakdown in soil, (c) one herbicide, imazapyr, was inactivated by binding to highly-oxidized tropical soil, therefore precluding its use as a soil-applied material, (d) natural revegetation was concomitantly rapid and diverse, (e) legitimate, subsistence crops occurring by chance in treated coca fields, in Peru, survived with little or no damage, (f) other crops were regrown successfully within 1-8 months after herbicide application at the lowest effective rate; and (g) the U.S. field site proved to be an excellent surrogate for herbicide studies used thus far in Latin America. No impediments to use in tropical areas against coca (or other drug-producing crops), based on environmental risk, was found for the four herbicides studied, i.e., glyphosate, hexazinone, imazapyr, and tebuthiuron.

17 Use Of Application Technology And Attractant-Based Products Improve Mexican Corn Rootworm Control And Reduce The Use Of Pesticides

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Corn rootworms are one of the most economically important pest of corn in the U.S. and has been chosen as the target of a national area-wide management program by USDA/ARS in cooperation with several universities and experiment stations. An attractant based pesticide, Slam, was evaluated as an area-wide management tool for Mexican corn rootworm, *Diabrotica virgifera zeae* Krysan and Smith. This pesticide uses 90-95% less toxicant than conventional adult control pesticides. An 8 mi^2 area was monitored over a two-year period for beetle abundance using a variety of techniques. Approximately 6 mi^2 was designated as the management area while the remaining area was considered as an untreated check area. Application parameters such as droplet size and application rate were found to have a significant impact on the efficacy of the product. The use of the most efficacious application methodology resulted in a 92-98% reduction in adult populations in the treated areas without having any detectable effect on the abundance of beneficial insects or mites. Effective adult control resulted in treated acreage decreasing from 3200 acres the first year of area-wide control to 800 acres the

second year. Overall beetle emergence and trap counts were also significantly reduced during the second year in those areas that were treated in the first year. Soil insecticides did not a significant impact on beetle abundance in those fields that were treated with the attractant-based pesticide the previous year. Root damage was reduced throughout the treated area in the second year of the control program.

18 Impact Of Cover Crops On Herbicide Efficacy And Soil Moisture In Corn

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Leguminous cover crops, such as hairy vetch, are being used in no-till corn production because they add significant amounts of nitrogen to the soil, minimize soil erosion, and suppress weed growth. Questions have been raised concerning the influence of the cover crops on the efficacy and fate of herbicides and the status of soil profile water balance in no-till corn production systems. A long-term study on relatively large-sized field plots (0.3 to 0.6 acres) is underway to address the above questions. Each plot contains four to seven groundwater monitoring wells and is surrounded by berms that direct all runoff through flumes which are instrumented to measure and sample runoff. Hairy vetch is planted in four of the eight no-till plots in the Fall and ammonium nitrate is applied in the Spring at 75 lb/ac (vetch) and 150 lb/ac (no-vetch) plots. One day after corn is planted, all plots are treated with paraquat (0.5 lb/ac), atrazine (1.5 lb/ac) and metolachlor (1.8 lb/ac). Soil moisture sensors are installed at 4, 8, 12, and 20 inches below the surface both in and between corn rows to provide continuous real-time moisture readings. In addition, each year "microplots" are also established within the large plots for weed assessment (emergence and species). This information will then be correlated with the soil solution herbicide concentrations of surface 2" of the soil. The following information is expected from this study: (1) changes in soil moisture in response to crop growth and rainfall events under vetch and non-vetch plots both in and between corn rows; (2) influence of the hairy vetch on concentrations of atrazine and metolachlor in soil (herbicide efficacy) and in runoff and groundwater; and (3) effect of the hairy vetch on weed suppression or growth.

19 Environmental Fate Of Fenamiphos Nematicide: Effects Of Formulation, Incorporation, Rainfall And Application Methods On Pollution Potential

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Fenamiphos nematicide provides excellent control of nematodes in many situations, without the atmospheric environmental impact and vapor phase soil mobility of the fumigant nematocides. It is, however, quite high in mammalian and terrestrial and aquatic species toxicity and breaks down in soils to two metabolites which are also toxic and nematicidal. All three chemicals are somewhat mobile in soil water and are of concern as potential aquatic ecosystem pollutants. Thus, investigating the environmental fate of this pesticide provides insights into many of the most important fundamental processes controlling the fate and behavior of all pesticides. This poster will summarize a group of multi-disciplinary experiments on weather, formulation and application method effects on efficacy, soil degradation and metabolite formation, and leaching and runoff potential, made possible by teamwork between three ARS Laboratories and University of Georgia Cooperators at Tifton, Georgia.

20 Management Of Microbial Processes In Cattle-Dipping Vats Containing Coumaphos

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Insecticide wastes generated from livestock dipping operations are well suited for biodegradation processes since these wastes are concentrated, contained, and have no other significant toxic components. About 400,000 L of cattle dip wastes containing approximately 1500 ppm of the organophosphate coumaphos are generated yearly along the Mexican border from a USDA-APHIS program designed to control disease carrying cattle ticks. Our results show that maintaining coumaphos suspensions at pH <5.5 prevents unwanted microbial degradation of the coumaphos and thus extends the useful life of the dipping solutions. In addition, this treatment leaves the dips amenable to disposal by biodegradation. We have developed a field scale biofilter capable of treating 15,000 L batches of spent dip containing coumaphos. This biofilter was used to reduce the coumaphos concentration in two successive 11,000 L batch trials from 2000 ppm to 10 ppm in approximately 14 days at 30 C. Our ongoing research is directed at manipulating microbial biodegradation processes in order to minimize and detoxify agrochemical wastes.

21 Ecological Characteristics Of Biological Control Of *Fusarium* Wilt Of Tomato Using Nonpathogenic *Fusarium* spp.

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Fusarium wilt diseases, caused by pathogenic formae speciales of the soil-inhabiting fungus *Fusarium oxysporum*, can cause severe losses in a wide variety of crop plants. For several crops, including tomato, *Fusarium* wilt is generally controlled by fumigation with methyl bromide. The objective of this research is to develop effective biological control of *Fusarium* wilt of tomato as an alternative to fumigation with methyl bromide. Previously, our research identified several isolates of nonpathogenic *F. oxysporum* that effectively controlled *Fusarium* wilt of tomato and other crops in greenhouse tests (50-80% reduction of disease incidence). To determine the suitability of selected isolates as biological control agents, various ecological characteristics of this biocontrol interaction were evaluated. Characteristics studied included the mechanisms of action, antagonist-pathogen inoculum density relationships, and efficacy in a variety of different soil types, against different races of the pathogen, and under different temperature regimes. Some isolates (and isolate CS-20 in particular) were effective in controlling *Fusarium* wilt diseases at low antagonist inoculum densities, at up to very high pathogen densities, in a variety of different soil types, and against all known races of the pathogen under a range of temperature conditions. Research is continuing to improve the level of effectiveness and consistency of biocontrol through further evaluations of the mechanisms, conditions, and requirements for optimal biocontrol activity, combinations of antagonists utilizing multiple mechanisms of action, field tests to study the efficacy of biocontrol under natural field conditions, and improved formulations and delivery systems. This work indicates that effective biological control of *Fusarium* wilt diseases is feasible and, with further research, has potential as a viable alternative to chemical control.

22 Development Of Analytical Methods For Multiple Pesticides In Water, Sediment, And Oysters

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Common analytical methods for pesticide residue analysis in environmental, food, and other types of samples are often time-consuming, labor-intensive, inefficient, and expensive. Furthermore, many of the existing methods lack multiresidue capability for both polar and nonpolar pesticides. For example, the National Oceanic and Atmospheric Administration's (NOAA) Mussel Watch Project has been monitoring shellfish for organochlorine insecticides (among other contaminants) since 1968, but the existing analytical methods do not detect relatively polar analytes such as many organophosphate, triazine, and other types of current-use pesticides. The Environmental Chemistry Laboratory entered into an interagency agreement with NOAA to develop new analytical methods to detect a variety of pesticides in water, sediment, and oysters. The methods would be used to determine pesticide concentrations in samples collected throughout the year from two tributaries of the Chesapeake Bay, namely the Patuxent and Choptank Rivers. The results of the analyses will be used to help determine the partitioning of the pesticides between the water, sediment, and oysters, and to obtain more information on the effect of agriculture in the region. More than 60 pesticides were selected for analysis by gas chromatography/ion-trap mass spectrometry for simultaneous quantitation and confirmation. Analytical methodologies evaluated included solid-phase extraction (SPE), supercritical fluid extraction (SFE), gel-permeation chromatography (GPC), and traditional soxhlet-based methods. For water, a polymer-type SPE cartridge, ENV+, was found to be superior to C-18 cartridges, and for oysters, a rapid SPE procedure using primary secondary amine and carbon cartridges was better than a time-consuming and solvent-intensive GPC clean-up step. The SPE procedure for oysters will be tested for sediments in an attempt to replace the GPC step in that procedure as well.

23 Management Approaches To Minimize The Impact Of Herbicides On Soil And Water Quality In The Mississippi Delta

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Environmental quality issues are interwoven with most of the research projects in the Southern Weed Science Research Unit; for example, evaluating soil quality changes or herbicide dissipation in soil systems where conservation tillage cotton is practiced. These evaluations will continue as conservation practices such as the use of cover crops, reduced tillage, and grass filter strips are adopted in Mississippi Delta cropping systems. Scientists are involved in several aspects of a Mississippi Management Systems Evaluation Area (MSEA) project. One part of this research is to characterize spatial variability of soil quality factors and other soil factors which might contribute to the efficacy and dissipation of herbicides. Spatial soil data linked to GPS coordinates will be useful in making site-specific chemical applications. Water from MSEA oxbow lakes are being evaluated for microbial population dynamics and other indicators of water quality in response to BMP's. In other studies, we are investigating cost-effective methods for the remediation of herbicide-contaminated soils using phytoremediation, use of organic amendments (biostimulation) and inoculate technologies.

24 Modification Of A Bacterial, Weed Biological Control Agent With Phytotoxin Genes

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The modification of a bacterial biological control agent of weeds with phytotoxin production genes was conducted to test if the ability to produce a systemic phytotoxin would affect the efficacy of the biological control agent. Triparental matings were conducted to mobilize a plasmid containing production genes for phaseolotoxin, anarginine-reversible phytotoxin, into *Pseudomonas fluorescens* D7, a bacterial biological control agent for downy brome (Bromustectorus), a weed in wheat. Thirty-nine of 50 isolates selected from the matings produced a toxin that was inhibitory to the growth of *Escherichia coli* BL-21, whereas the wild-type *P. fluorescens* D7 isolate did not inhibit the growth of *E. coli*. The growth inhibition of the putative transconjugants was partially or totally reversed when arginine was included in the bioassay. Polymerase chain reaction (PCR) analysis of ten of the putative transconjugants with high levels of toxin production demonstrated that the genes for phaseolotoxin production were present, whereas no PCR product was produced by the original strain. Whether the genes remain as autonomously replicating plasmids or are integrated into the genome is yet to be determined. Similar matings will be conducted with two other Pseudomonads (*Psuedomonas syringae* 3366 and *Pseudomonas syringae* 2V19) identified as biological control agents of downy brome. The biological activity of the toxin-producing transconjugants will be evaluated to determine what effect the genetic modifications have on the efficacy of the biological control agents.

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25 Biological Control Of Fusarium Wilt Of Tomato And *Phytophthora* Blight Of Pepper

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One feasible approach to reduce pesticide risk in the environment is the implementation of biological control for soilborne plant pathogens of economic crops. A biological control system can be used by itself or within integrated pest management (IPM) to include crop rotation, cover crops and minimal tillage (sustainable agriculture). Bioassays were conducted in the greenhouse to examine the effect of seed treatment and root dipping with biological control agents on the reduction of damping-off of tomato and pepper caused by pathogenic species of *Pythium*, *Rhizoctonia*, and *Sclerotium*, and on the reduction of *Fusarium* wilt of tomato and *Phytophthora* blight of pepper caused by *F. oxysporum* and *P. capsici*, respectively. Seeds were treated with the biocontrol fungus *Gliocladium virens* (G1-3) and the biological control bacterium *Burkholderia cepacia* (Biological control-F), alone and in combination, and planted in seedling trays with soilless mix infested with indicated pathogens. In addition, at transplanting, seedlings were root-dipped with the biological control agents. Results showed that seed treatments with the biological control agents significantly increased seedling stands for both crops. Application of the biological control agents in a root dipping significantly reduced the severity of *Fusarium* wilt on tomato and *Phytophthora* blight on pepper, and effectively increased plant height, fresh weight, and root length and dry weight of both crops. These beneficial results were subsequently demonstrated in the field. The results indicate the potential of biological control for disease management in economic crops grown within a sustainable agriculture system.

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26 Discovery, Fermentation And Formulation Of Microbial Pesticides

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Microbes have long been known to cause disease and death of insects and plants and to suppress progression of disease causing organisms. For approximately 80 years, these microbes have been used in efforts to reduce pest populations but efforts at wide scale use, with a few exceptions, have not been successful. There are three basic steps to developing an effective microbial pesticide acceptable for commercialization: 1) discovery of new isolates of microbes that have an adequate host range, act quickly to kill or reduce activity of pests, and are amenable to deep tank fermentation; 2) development of inexpensive deep tank fermentations for producing large quantities of active and stable microbial propagules with enhanced biological control efficacy; and 3) invent methods of formulating biomass of biological control agents to extend shelf life, increase efficacy and extend residual activity in the field.

Scientists at NCAUR have been involved in all three stages of microbial pesticide development. Examples include: discovery and patenting of gram negative bacteria (*Enterobacter cloacae* S11:T:07 and *Pseudomonas fluorescens* P22:Y:05 for controlling dry rot of potato tubers); fermentation of *Paecilomyces. fumosoroseus*, a fungal pathogen of sweet potato white fly; fermentation of non-phytotoxic seed inocula of *P. fluorescens* for control of take all disease of wheat; formulation of *Bacillus thuringiensis* for enhancing acceptance by insects, protection of UV-sensitive insecticidal components, and prevention of wash-off by rain; formulation of *P. fumosoroseus* for extending shelf life; and formulation of highly UV-sensitive insect pathogenic viruses for increasing field residual activity. Interest from producers wanting to reduce conventional chemical pesticide use has been high and these projects have received support from industry including CRADA and licensing agreements.

27 Reduction In Fungicide And Nitrogen Fertilizer Use In Staked, Fresh Market Tomato Production

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In the production of fresh market vegetables, several off-farm inputs of plastic, nitrogen fertilizer, fungicides, insecticides and herbicides are routinely used. In the sustainable programs at the Beltsville Agriculture Research Center, we are developing systems that reduce these inputs. We are carrying out experiments utilizing four different culture methods (black plastic mulch, hairy vetch mulch, dairy manure compost and bare ground) along with three different foliar disease management treatments (nothing, weekly fungicide treatment and a foliar disease forecasting model, TOMCAST) to develop sustainable systems for the production of staked, fresh market tomatoes. Data concerning disease development and yield are being obtained. It appears that foliar disease pressure is reduced within tomatoes grown in hairy vetch mulch in relation to the other cultural treatments. In addition, using the TOMCAST model as a disease management tool can reduce fungicide applications by about 50% without a reduction in yield. Modifying the TOMCAST model specifically to accommodate the hairy vetch mulch system may reduce fungicide use even further. It appears that sustainable production systems can be developed that are economically sound and reduce the reliance on some off-farm inputs of plastic, nitrogen fertilizer and pesticides.

28 Alternatives To Pesticide Use For Controlling Pests Of Tropical Crops

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Recent advances in understanding plant-microbe interactions and in the engineering of plants for resistance to microbes offers potential for the reduction in pesticide use to control pests and diseases of papaya, pineapple, and sugarcane in Hawaii. The papaya ringspot virus disease (PRV), spread by an aphid, greatly reduced crop production until resistance to PRV was developed by transformation of susceptible lines with a viral coat protein gene. Pesticides used to control several papaya fungal diseases, notably *Phytophthora* and Anthracnose, might be reduced by transforming plants with suitable pathogenesis related genes to confer resistance. A concern of the Hawaiian pineapple industry is the Mealy Bug Wilt Disease due to viral infection by mealybugs which are tended by ants. This pest and disease complex requires use of several pesticides which might be reduced if virus resistance can be engineered analogous to what was done with papaya. Lack of pineapple resistance to nematodes has necessitated soil fumigation with methyl bromide, which will soon lose this registered use. Transgenic resistance to nematodes is reported in other plants and has potential for pineapple. These alternatives to pesticide use will contribute to sustainable tropical crop production.

29 Site-Specific Pesticide Application Technology for the Southeastern Coastal Plain

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Agricultural research scientists at the Florence, SC, location have been conducting extensive research to develop a computer-controlled, variable-rate center pivot irrigation system. The goal of the project is to reduce agricultural chemical (nutrient and pesticide) application on crops by using the pivots to apply chemicals on a site-specific basis. Chemical application on a site-specific basis delivers the chemical where, and at the rate it is needed, instead of blanketing the field with a uniform rate. In this manner, lower amounts of agricultural chemicals are used and the risk of ground and surface water contamination can be reduced. Currently, the location has two center pivot irrigation systems that have been modified to provide delivery of variable rates of irrigation water and agricultural chemicals. Approaches to custom-apply the agricultural chemicals by characterizing important topsoil physico-chemical properties and weed density under the pivots are currently being evaluated.

30 Oxidation Strategies To Remediate Amitraz Waste And Soil Contaminated With Aniline-Based Pesticides

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Amitraz is used by APHIS to control cattle ticks in the Commonwealth of Puerto Rico and is being tested for use in Texas. APHIS generates approximately 250,000 gallons of amitraz waste each year during treatment operations. Amitraz is readily hydrolyzed in water and in soil giving rise to 2,4-dimethylphenyl formamide and ultimately to 2,4-dimethylaniline. Aniline moieties frequently serve as building blocks for a wide range of pesticides. However, anilines are often more toxic than the parent pesticide as is the case with amitraz and 2,4-dimethylaniline. Thus, the objective of this project is to develop strategies to decrease the toxicity of aqueous amitraz dip-vat and spray-dip wastes and soils contaminated with aniline-based pesticides.

Oxidation of amitraz with ozone does not afford the toxic aniline by-products. Furthermore, ozone may also provide an alternative to steam injection soil remediation processes. Steam injection processes are hindered by rapid subsurface condensation and slow diffusion rates. Ozone, existing as a gas at room temperature, has better diffusive properties and will more rapidly distribute through soil. Due to the high affinity of ozone for anilines and aniline-based pesticides, we expect initial oxidation of the compounds will be sufficiently rapid to effectively remove or substantially reduce the aniline content of the wastes, and render biodegradable products. Preliminary evidence suggests that ozone will effectively oxidize soil bound anilines. Optimization of this soil treatment process will require that the effect of soil organic matter, soil moisture, and permeability on ozonation efficiency be delineated. Ultimately, this method of stripping bound soil residues using ozone should have significant benefits for pump and treat processes and similar processes which are hindered by slow contaminant desorption rates.

31 Development Of Nontoxic Particle Film Technology For Broad-Spectrum Arthropod Pest Control

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Conventional chemical insecticides are mainly physiological toxins that offer broad-spectrum arthropod control. Concerns over food safety ground water, and the environment have brought these chemicals under close scrutiny by federal regulatory agencies. The expected outcome is that use of a number of these pesticides will no longer be allowed. For example, one of EPA's major policy goals is a 50% reduction in the use of all pesticides by 2005. We have developed a new nontoxic arthropod pest control technology that is based on inert particle materials. A particle product resulted from this research that was recently granted a three-year EPA *Experimental Use Permit* and temporary *Exemption from Tolerance*. Field tests conducted in 1997 showed several of these materials were very effective against a broad range of tree and small fruit pests including mites, leafhoppers and Japanese beetle. Beneficial arthropods such as lady beetles and honey bees are not killed and normal pollination of the crop resulted. These encouraging results have spurred further commercial development on sprayable nontoxic formulations of these particle materials. Progress thus far indicates that this particle technology will soon become a new alternative to conventional chemical pesticides.

32 Surface Runoff Of Pesticides To Reclaimed Agricultural Wetlands In Maryland

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Wetlands have long been known for their excellent qualities of buffering runoff especially sediment loss, and nutrient containment. They are also suspected of helping retain pesticides and encouraging their degradative loss. For these reasons and their obvious esthetic and wildlife enhancement qualities there are several initiatives within USDA to encourage reclamation of wetlands in agricultural settings. In 1996 our lab initiated a program to address the pesticide buffering capabilities of some selected Eastern Shore wetlands that neighbor agricultural fields. The study is a cooperative effort managed by our laboratory and involves staff from the Smithsonian Environmental Research Center and the Wetlands Institute of the Natural Resources Conservation Service. Initially, a major goal of the study was to assess the possible impacts of retained pesticides on living resources within these ecosystems. To accomplish this we analyzed filtered water collected weekly as grab samples from five wetlands. The following pesticides were detected, atrazine, simazine, cyanazine, acetochor, alachlor, metolachlor, and glyphosate. Rain samples were also found to contain many of these pesticides. In 1997, the program was modified and expanded to evaluate and compare the transport and fate of pesticides entering and leaving wetlands and to compare these measurements with ongoing water quality studies underway by Smithsonian personnel. Weekly flow-weighted composite samples were collected at the inflow and outflow of two different wetlands. One of the watersheds received low agrochemical inputs while the other received more conventional levels of chemical pesticides. Results will give more quantitative information to farmers and policymakers on the value of wetland areas in protecting surface waters from agricultural runoff.

33 Assessing The Impact Of Vegetable Production On The Environment: Plastic Mulch Versus Organic Mulch

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Conventional farming systems have traditionally relied on intensive cultivation and the application of large quantities of agrochemicals which often results in soil erosion and the off-site movement of agrochemicals to groundwater, surface water, and susceptible ecosystems. Black polyethylene mulch is frequently used in vegetable production to control temperature and weeds and maintain soil moisture, but are associated with excessive runoff. Recently, agricultural runoff, which may contain pesticides, nutrients, and soil, has been implicated in the failure of shellfish in commercials nurseries on the Eastern Shore and in contributing to the *Pfiesteria* p. outbreaks in the Chesapeake Bay. The objective of this project is to quantitate the fate of pesticides and nutrients and predict their potential impact on the environment using two different management practices, the conventional plastic mulch system (black polyethylene) and a sustainable cover crop system (hairy vetch). Water movement dynamics is key to understanding the fate of agrochemicals. Real-time monitoring systems and automated runoff flumes have been installed to continuously monitor the infiltration of water into the soil and its transport across the soil surface. Collected water-runoff samples will be analyzed to measure runoff rate, sediment loss, and the concentration,

transport, and degradation of agrochemicals in the runoff. Preliminary data from the current work has indicated that runoff from plastic mulch is two to ten times greater in quantity than runoff in organic mulch systems. The knowledge gained from this project will allow development of better management practices that will minimize soil erosion and agrochemical loss, and thus reduce the negative impact of vegetable production on surrounding ecosystems.

34 Improved Agricultural Sustainability In The Palouse Through Competition, Biological Control, And Cropping Systems

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The goal of ARS scientists at Pullman, WA is to develop more sustainable practices for the dryland wheat growing areas of the Pacific Northwest. Research is being conducted in three major areas of weed science. The first area of research is concerned with crop-weed interactions. The objectives of this research are to identify winter wheat traits which enhance competitiveness against winter annual grasses using commonly grown winter wheat cultivars and path analysis with latent variables, and to quantify the effect on competitiveness of growth parameters such as plant height and date of maturation using near isolines of winter wheat. This area of research may reduce our dependence on herbicides to control problem winter annual grass weeds in winter wheat.

The information garnered from these studies will have applications in other winter wheat growing areas of the world. The objectives of the second area of research are to develop practices to efficiently use the soil microbial community to reduce weed populations. Molecular analyses are a tool being used to follow changes in soil and seed microbial communities to determine factors leading to increased weed suppression. Soil microbes can be used to increase seed decay and to reduce the vigor of winter annual grass weeds. Weeds that have been weakened by these soil microbes can be suppressed even more by a competitive winter wheat crop. The third area of research is focused on developing cultural practices to further enhance the sustainability of dryland farming. This includes changing seeding density, seed size, and crop rotations, while reducing tillage. Changes in cultural practices can enhance crop competitiveness and improve the economic sustainability of the farming system by reducing the amounts of pesticides in the system.

35 Influence Of Water Table Management On Runoff And Leaching Losses Of Soil-Applied Pesticides

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The utility of conventional subsurface drainage for lessening runoff losses of soil-applied pesticides from agricultural crop lands is well known. Subsurface drains with controlled water table capability have an additional potential advantage of holding leachate in the soil profile to allow soil-applied chemicals to continue their desired action and in addition to undergo degradation processes before being pumped into a surface water way. The present paper will report results of controlled water table management on runoff and leaching losses of atrazine, metolachlor, pendimethalin, and chlorpyrifos from Lower Mississippi River Valley soil.

36 The Beltsville Sustainable Agriculture Demonstration For Reduced Tillage Cropping Systems

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The Beltsville Sustainable Agriculture Demonstration Site was developed to evaluate the efficacy of sustainable agricultural strategies that are compatible with reduced-tillage systems required on erodible land. Cultivation of the soil is an important component of many sustainable agricultural strategies. Plowing soils prior to planting kills weeds and releases nutrients from existing vegetation. Cultivation incorporates animal manure or other soil amendments which may substitute for commercial fertilizers. Interrow cultivation for weed control after planting can substitute for herbicides. In recent decades, however, cultivation has become associated with loss of soil organic matter, deterioration of soil structure, and increased soil erosion which can reduce the sustainability of agricultural soils. There is a need to develop reduced-tillage sustainable agricultural systems to preserve the viability of erodible land. This is particularly challenging because reduced-tillage systems traditionally have required more fertilizer and herbicide inputs than conventional-tillage systems to be successful.

A 15-acre site on the South Farm of the Beltsville Agricultural Research Center with 2 to 15% slopes has been set aside for demonstrating reduced-tillage sustainable strategies. Approximately 1/3-acre plots were established in 1993 with four treatments and four replications. Each treatment follows a two-year rotation consisting of corn in the first year followed by winter wheat and soybean in the second year. Crops from both years of the rotation are present every year. Treatments include: 1) no-tillage with recommended fertilizer and herbicide inputs; 2) no-tillage with crown *vetch (Coronilla varia* L.) living mulch suppressed by herbicides; 3) no-tillage plus winter annual cover crops (hairy vetch [*Vicia villosa* Roth] before corn and wheat before soybeans) with reduced fertilizer and herbicide inputs; and 4) a chisel plowed system with cow and green manure as nutrient sources and rotary hoe plus cultivation for weed control.

37 Colorado Potato Beetle Control On Tomatoes Using Hairy Vetch Mulch And Reduced Rates Of Imidacloprid

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The effects of black plastic versus hairy vetch mulch on Colorado potato beetle (CPB) density and damage in staked fresh-market tomatoes was examined by releasing beetles at a density of 2 per plant during the first 3 weeks after transplanting. Treatments were applied to 45 ft. x 45 ft. plots of Sunbeam tomatoes at Beltsville, MD. Half of the plots received transplants that had been treated with a seedling drench of imidacloprid at a reduced rate of 1 ounce per acre prior to transplanting, and the other half were not treated. The insecticide treatment provided season-long control, although summer generation CPB pressure was low. On the untreated plots, CPB establishment an damage were lower on plants mulched with vetch. Predator density both in the foliage and on the ground was higher in the vetch plots.

38 Chemicals From Insects, Plants, And Fungi With Novel Activity

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Alternatives to petroleum-based chemical pesticides may come from a variety of sources. Plants, fungi and insects have all evolved chemicals that impact the environment around them. These chemicals may be harnessed as safe alternatives to pesticides or as tools useful for determining critical aspects of pest behavior and ecology. At NCAUR, scientists have discovered several novel chemicals from these sources and are currently determining practical uses. Pheromones from nitidulid beetles have been isolated, identified, and synthesized. These previously unidentified chemicals have been shown to be useful for mass trapping and monitoring beetle populations by using a novel trap developed by NCAUR scientists. Volatile chemicals produced by yeast and fungi from wound sites in corn plants are also highly attractive to the beetles. These beetles are important vectors of *Fusarium moniliforme* and *Aspergillus flavus*, fungi that produce mycotoxins. A pheromone isolated from the pepper weevil by NCAUR scientists is currently being marketed for monitoring this important insect pest in pepper fields to help precisely time insecticide applications. Chemicals isolated from fungal sclerotia (resting stages for certain fungi) have been shown to affect insect growth and development. Other chemicals isolated from mustard plants are herbicidal, fungicidal, and nematicidal. Mycoparasite invasion of fungal sclerotia and ascomata can involve antibiosis and we are presently investigating this specialized group of fungi as sources of novel antifungal antibiotics. Efforts to determine factors affecting aflatoxin production have resulted in new techniques to determine physiological response of the fungus to chemicals and discovery of corn components that decrease toxin production. This information will be useful in directing germplasm screening and in breeding corn for resistance to *A. flavus* growth and/or aflatoxin production. Many of these technologies have attracted interest from industries involved in the development of novel and safe chemicals for pest reduction.

39 The Root Zone Water Quality Model: A Computer Model for More Realistic Prediction of Land and Water Pollution By Pesticides and Other Agricultural Chemicals

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Computer simulation models are the only way to analyze and integrate the numerous complex and interdependent processes that control the fate and behavior of agricultural pollutants pesticides and fertilizers in the environment. The root zone water quality model is a new simulation program which provides a richly detailed description of such processes. The agricultural environment is divided into four compartments: plant foliage, plant residue, soil surface, and soil subsurface. Chemical transformations within each compartment, chemical transport between compartments, and chemical losses from the system are tracked as a function of the properties of the chemicals and the hydrology, meteorology, crop growth, and cultural practice effects in each compartment. The large data requirements of the model are compensated for by scenario development for standard crop situations and by a built-in database of soil and chemical properties. I/o uses the full gui capabilities of *Windows 95.* The model has the potential to provide, for standard scenarios, a more accurate and detailed prediction of pesticide dynamics in soil, terrestrial and aquatic environments.

40 Impact Of The Imported Fire Ant On Biodiversity: Standardized Spatial Monitoring Of Foraging Interactions

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The imported fire ant is an invasive species that has gradually spread to all or parts of 13 states. In recent years, the negative impact of this species on biodiversity has been recognized. We are developing methods to quantify the impact of fire ants on biodiversity using spatial analysis and precision targeting to develop and implement reduced-risk management strategies. Herein, we compare two bait/monitoring approaches, used in combination with spatial statistical analysis, to assess relative abundance and foraging profiles of several species of ants, setting the stage for future comparisons with the introduction of interventions to mitigate fire ant populations and enhance/safeguard biodiversity of the ecosystem.

41 Reducing Methyl Bromide Emissions with High-Barrier Films

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There are many soil-chemical processes which affect the fate and transport of fumigants in agricultural soils. Three factors must be controlled to reduce emissions while maintaining adequate efficacy: containment, degradation and soil-gas distribution. Probably the most reliable method to reduce the amount of methyl bromide (mebr) leaving the treated soil involves the use of high-barrier plastic films. To demonstrate this, a recent field experiment was conducted using the traditional high-density polyethylene (hdpe) and a high-barrier film (hbf), hytibar (klerks plastic, belgium), to cover triplicated field plots treated with mebr at a rate of 280, 210 or 140 kg/ha. At the beginning of the experiment, two bags containing citrus nematodes (*Tylenchulus semipenetrans*), yellow nutsedge seeds (*Cyperuse esculentus*) and fungi (*Rhizoctonia solani*) were placed 10-15 cm deep in each plot to determine the effectiveness of the fumigation. During the course of the experiment, the volatilization rate was continuously measured over 3 hour intervals using two or more flux chambers. After the experiment, soil bromide concentration was measured to provide information for a mass balance. It was found that mebr emissions were reduced from approximately 60% using current practices to less than 5% when hbf together with an 210 kg/ha application rate and a 10-day cover period were used. Hbf offer several advantages for reducing fumigant emissions and include: the properties and condition of the film are known in advance and films are more uniform in space and time compared to soil-based methods.

42 An Integrated Approach to Reduce Agrochemical Impact in Pacific Northwest Grass Seed Agriculture

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Major questions exist regarding the identification of sustainable cropping systems practices needed to produce grass seed crops in the Pacific Northwest in the absence of open-field burning. The impact of significant changes in cropping practices necessitates identification of new optimal economic systems for long-term sustainable production.

Temperate grass seed cropping systems in the Pacific Northwest have historically relied on intensive cultural practices to produce high quality seeds that meet regulatory standards set by the *Federal Seed Act*. Large quantities of agrochemicals, intensive field disturbance practices, and open-field burning have been used to establish new crops, control diseases and weeds, achieve high seeds yields, and dispose of post-harvest residues on approximately 274,000 acres of perennial grasses in the Willamette Valley. Due to state legislative actions restricting open-field burning in Oregon and Washington and the need for *Federal Clean Water and Air Acts* standard compliance, questions exist regarding the impact of temperate grass seed production practices on environmental quality. Historically, most grass seed cropping systems have not utilized rotational crop diversity. As such, these traditional systems have not realized the beneficial effects of alternative crop life histories in rotation sequences. These historic systems relied on maintaining grass seed stands for six or more years and utilized open-field burning to dispose of crop post-harvest residues. Substantial investments into high-energy-consuming equipment were needed to prepare fields for planting. Additionally, large amounts of pesticides and fertilizers were used prophylactically without a clear understanding of their efficacy or interactions with other production factors to achieve economically viable yields. Concerns by urban and other non-agricultural interests have led to legislative mandates restricting the use of open-field burning and have also called into question the impact of agricultural lands on water and air quality by supposed agricultural non-point source pollutants. These concerns have necessitated investigations into alternative grass seed cropping systems that are both economically sustainable and environmentally protective.

The purpose of this relatively long-term research is to implement decision management information tools that can predict the optimal sequence of cropping practices needed for economic grass seed production in the absence of open-field burning. It is our intent to identify strategies that account for dynamic system changes resulting from changes in soil quality parameters, shifts in microbial and faunal populations, and crop response as a result of new cropping system technologies. Our research will develop integrated best management systems that utilize minimal chemical and energy inputs through the use of prescription-based pest and fertilizer management and no-till crop establishment. Early recognition of system changes and ongoing adjustments in practices are required if consistent and optimal economic seed production is to be achieved. Economic and environmental impact assessment models are being developed to determine the most effective alternative management strategies that result in optimal overall system economic sustainability and environmental protection.